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Early American Observatories*

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(Continued from page 474)

PART II

Other Early American Observatories

Opinions differ as to which was *The First Astronomical Observatory in America.* To answer this question it will be necessary to consider briefly all astronomical observatories in America of all kinds built and equipped before 1840.

John Quincy Adams, President of the United States, in his first annual message to Congress on December 6, 1825, said:

> Connected with the establishment of a university, or separate from it, might be undertaken the erection of an astronomical observatory, with provision for the support of an astronomer, to be in constant attendance of observation upon the phenomena of the heavens; and for the periodical publication of his observations. It is with no feeling of pride, as an American, that the remark may be made that, on the comparatively small territorial surface of Europe, there are existing upward of one hundred and thirty of these light-houses of the skies; while throughout the whole American hemisphere there is not one.

In 1832, Sir George B. Airy, Astronomer Royal of England, in his report on Astronomy before the British Association closed by saying that, as for the United States, he did not know of the existence of a single public observatory within the limits of the entire country.

We may not agree entirely with the above statements but nevertheless the wave of observatory building did not reach America until between 1830 and 1840.

In considering the early American Observatories, it is convenient to classify them in two entirely different ways. In the first place they may be classified as: (1) temporary observatories; (2) makeshift observatories; (3) mere repositories of apparatus; and (4) regular permanent observatories. A regular permanent observatory should have piers for the mounting of the instruments, roof shutters or a revolving dome so that the observations could be made from inside the building, and the construction of the building should be such that it would normally last for a considerable number of years. Observatories may also be classified as state, private, and public. By a state observatory or institution is meant one which is maintained by the United States Government, or by

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some state, or in the early days by some colony. The private observatories were owned by individuals and were for three different purposes: (1) for gazing purposes to satisfy intellectual curiosity and interest; (2) for research work; (3) for private gain. This last would be the case if the observatory were used to determine time to rate chronometers which were being constructed or repaired by the owner of the observatory. By a public observatory is meant one owned by some educational institution. These were for astronomical instruction and research. The stimulus which led to observatory building in America came from three sources. The first was a desire to observe astronomical occurrences and do research work. A transit of Venus occurred in 1769 and expeditions were sent long distances to observe it. It aroused a very general interest in Astronomy. A previous transit in 1761 had not been as favorable and was not as widely observed. In 1833 came a brilliant display of Leonids and everyone was looking forward with eagerness to the return of Halley's comet in 1835. In the second place the needs of surveying on a large scale brought Astronomy into prominence. It was said in the early days that a mathematician or an astronomer could not earn his living without being either a surveyor or a clock-maker or both. In the third place the needs of navigation stimulated the building of observatories.

A consideration of all the observatories in America of all kinds built and equipped prior to 1840 will illustrate many of the statements which have been made. There are eleven observatories in such a list; one was a private observatory, one was a private observatory which developed into the Harvard College Observatory first at Dana House and later in its present location, one was a private observatory which developed into the Depot of Charts and Instruments and later into the U. S. Naval Observatory. Eight were erected by educational institutions. The surveying stations or temporary astronomical observatories in connection with the early boundary surveys and in connection with the survey of the coast are not included in this number. In fact they are not considered to have been astronomical observatories in any proper sense.

Early Boundary Surveys

Boundary disputes came up everywhere in the colonies. Many colonial grants had been based on parallels of latitude or meridians of longitude. It was no easy matter to mark out these lines. Right here in Williamstown a wrongly run parallel probably places Williamstown in Massachusetts instead of Vermont. The most famous boundary historically is without doubt the Mason and Dixon line between Maryland and Pennsylvania. Mason was an astronomer as well as a surveyor and more astronomical observations were probably made in connection with this line than any other. The dispute which arose between William Penn and Lord Baltimore about the borders of their colonies continued after the death of both parties. In 1732 a first agreement was reached. In 1763 Charles Mason and Jeremiah Dixon, two skilled surveyors,

were sent over from England by the Proprietaries to mark the line. Mason had been Bradley's assistant after he had retired as head of the Greenwich Observatory. In 1764 they entered upon their task with good instruments and a number of axemen to serve as helpers. By the middle of June, 1765, they had traced the parallel of latitude which was 39° 43′ 26″.3 N to the Susquehanna. A year later they climbed the Little Allegheny. In 1767 they were 244 miles from the Delaware River. Time, azimuth, and latitude and longitude were frequently determined by astronomical observations.

The following example is taken from the *Journal of the Senate of the State of Delaware,* 1841 on. On page 64 commences:

> Col. Graham's Report to the Commissioners, Washington, February 7, 1850.
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> To Messrs. H. G. S. Key, Joshua P. Eyre and George Read Riddle, commissioners for adjusting and re-fixing certain parts of the boundaries of the States of Maryland, Pennsylvania and Delaware.

On page 67 of this report occurs the following note:

> Note 2.—The latitude of the north wall of this house, occupied in 1763 by Thomas Plumstead and Joseph Huddle, was determined by Messrs. Mason and Dixon, from astronomical observations in 1763-64 with a zenith sector to be 39° 56′ 29″.1.

It is interesting to note the instrument used and the accuracy which was supposed to have been attained.

Professor W. C. Rufus of the University of Michigan in his article "Astronomical Observatories in the United States Prior to 1848" in Vol. XIX of the *Scientific Monthly* has this to say:

> Mason and Dixon arrived from England in 1763 to settle a boundary dispute between Pennsylvania and Maryland. Their first work in this country was to establish a surveying station and to determine its position with great care and accuracy. The building erected for this work just south of the city of Philadelphia, was called Mason and Dixon's Observatory. Extensive astronomical observations were made in 1763 and 1764, and the reduction of the data has been styled the first astronomical computation in America.

Professor Maurice J. Babb of the University of Pennsylvania in his article "David Rittenhouse" in Vol. LVI, No. 3, of the *Pennsylvania Magazine of History and Biography* has this to say:

> We know that . . . Mason and Dixon, after a short stay at the Plumstead house, No. 30 South Street, designated as the most southerly point of Philadelphia, loaded their instruments in a wagon and went 31 miles directly to what is now called Harlan's Corner, near the Chester County Poor Farm and spent the Winter there, and that there remains in the shifting sands of a field above the house the so-called Star Gazer's stone. Immediately south of the house was their observatory from which they measured a south line crossing the Brandywine three times in the first mile. They continued this and on a part of it measured out a degree of latitude. This line runs over four miles East of the Eastern boundary of Maryland. They probably didn't want to make any of their preliminary calculations on Lord Baltimore's territory. Finally they measured fifteen miles south from the then position of the stone which was in the latitude of the most "southernly part of Philadelphia." From this point they proceeded to locate the Northeastern corner of Maryland and to lay

out Mason and Dixon's line. The method was to start off from each station, on the arc of a great circle just as steamers do today, then at intervals they checked back South on the Meridian to the latitude of their starting point. In this manner they continued until stopped by Indians.

There are two articles by Mason and Dixon themselves in the *Transactions of the Royal Society*, Vol. 58 (1768). The following are certain extracts from these articles:

> The Place where these observations were made (the Forks of the River Brandiwine) is the Northernmost Point of the Lines that were measured for a degree of latitude . . . it lies 31 miles West by measurement; and 10".5 South of the Southernmost point of the City of Philadelphia, as found by the Sector.
>
> N.B. The clock was firmly secured to a piece of timber, 22 inches in breadth, and five inches and a quarter thick; the said piece of timber was set four feet into the ground which was composed of a very firm, dry, hard clay. The clock was placed in a tent, with Fahrenheit's thermometer hung to its side.
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> Time was determined by equal altitudes.
>
> The eclipses of Jupiter's satellites were observed with a reflecting telescope of one foot focus that magnified 70 times.
>
> The astronomical observations had been taken with an excellent sector of six foot radius constructed by Mr. Bird.

The three chief surveying stations or astronomical observatories, if we wish to call them that, were thus located at the Plumstead house in the most southernly part of Philadelphia; at the Forks of the Brandywine, 31 miles west; and at a point about 15 miles south which was the beginning of the Mason and Dixon line. At one of these the clock was attached to a post and covered with a tent. Time was determined by means of equal altitudes using the instrument in the open. Longitude was determined by eclipses of Jupiter's satellites using the instrument in the open. These stations were very temporary, being used for two or three years only. Most agree that they should be considered simply surveying stations and not astronomical observatories.

The United States Coast and Geodetic Survey

During the administration of Thomas Jefferson, Congress passed an act February 10, 1807, authorizing the establishment of a Coast Survey. It was a bureau placed under the Secretary of the Treasury. The latter, with the approval of the President, issued a circular setting forth a project of a survey, inviting the attention of scientists to it, and requesting plans for carrying it into effect. In this project the proposed operations were to consist of: (1) the ascertainment, by a series of astronomical observations, of the true position of a few remarkable points on the coast; (2) a trigonometric survey of the coast between these points; and (3) a nautical survey of the shoals and soundings of the coast, of which the trigonometric survey was to supply the basis. The plan of work adopted was one which had been submitted by Ferdinand Rudolph Hassler, a Swiss engineer of considerable experience, who at the time was instructor of mathematics at West Point. Hassler was appointed first superintendent of the "Survey of the Coast." Nothing was done,

due to the lack of instruments, until July 11, 1811, when Hassler was sent to Europe to have the necessary instruments constructed and to purchase others.

There are several reports by Mr. Hassler and the following is an extract from one dated Weasel Mountain, August 6, 1817:

> The eighteen-inch multiplying circle, similar to the one I lent for the determination of the northern boundary, depending, by the nature of its construction, very little on its adjustments, has given me the least trouble, notwithstanding its few adjustments were lost also. I shall stand more in need of this instrument in the field than I thought, as I shall have to observe in lighthouses, steeples, high buildings, where theodolite kind of instruments cannot be used. Besides this, the astronomical observations are to be made by it.
>
> This kind of instrument being best adapted to supply, in an observatory, (the construction of at least one of which becomes now indispensable to the advancement of the survey) the absence of the mural instrument. I must wish very much that the one lent for the boundary, may be returned immediately after that service.

The various reports of Mr. Hassler are interesting in a great many ways. In the first place they show clearly that Mr. Hassler never thought of his temporary, makeshift observation stations as constituting astronomical observatories in any sense. Furthermore, as early as 1817, he was adding his voice to the chorus which was already clamoring for at least one national astronomical observatory in the United States. Incidentally the instruments used and the methods of determining time, azimuths, latitude, and longitude are apparent.

The United States Naval Observatory

Thomas Jefferson, as an amateur, made astronomical observations and at one time had a plan for a national observatory.

Barlow's "prospectus of a national institution" in 1806 included plans for a national observatory.

Hassler in 1807 and again in 1817 urged the erection of a national observatory.

James Monroe in 1812, when he was Secretary of State, urged it.

Some of the leading professors of Bowdoin College memorialized Congress to establish it.

William Lambert of Virginia, an amateur astronomer, from 1809 to 1824 made frequent representations to Congress about it.

John Quincy Adams, when President, in 1825, as is stated in the opening paragraph, urged it.

In 1827, Mr. James Courtenay of Charlestown published a pamphlet urging the establishment of a national observatory.

The call for a national observatory grew louder and louder as the years passed but Congress did nothing.

On Dcember 6, 1830, the Secretary of the Navy established the Depot of Charts and Instruments and placed Lieutenant L. N. Goldsborough in charge. He was directed to collect from the commandants of the various navy yards, the nautical instruments, books, and charts not being

used and to deposit them in the Depot. Here they were arranged, marked, and put in condition for reissue. Among his other duties were: the determination of the errors of chronometers; the translation of all books, charts, pamphlets, and other nautical information into English; the reduction of all charts to the meridian of Greenwich. The strange title, Depot of Charts and Instruments, was perhaps chosen to camouflage the idea that there was anything astronomical about it. In 1833, Lieutenant (later Captain) Charles Wilkes, a scientist of note, succeeded Lieutenant Goldsborough. He became thoroughly provoked by the procrastination of Congress in providing a suitable building for the Depot and he built his own astronomical observatory with his own money on Capitol Hill, about 1000 or 1200 feet north of the Capitol. It was a little building about 16 feet square and contained a 4-inch transit instrument made by Troughton in England in 1815 and loaned by the Coast Survey. He also had a 3½-inch portable telescope, a transit instrument, a sidereal clock, and other equipment. In 1836 he went to Europe to procure instruments for his expedition to the Pacific and the South Seas. The expedition started on its mission in 1838 and returned in 1842. In the meantime, in 1836 Lieutenant James M. Gilliss was ordered to Washington and was soon put in charge of the Depot of Charts and Instruments. He obtained as additional equipment a portable 4½-inch achromatic telescope, equatorially mounted, a variation transit, a comet seeker, a sidereal chronometer, and later a sidereal and a mean time clock. In 1838, when Captain Wilkes took charge of the exploring expedition, he recommended that a series of observations should be taken in this country during his absence upon such celestial phenomena as might be available for the better determination of his longitudes and their reference to some meridian at home. His recommendation was sanctioned and the observations were made in Washington by Lieutenant Gilliss and continued until 1842. In Dorchester, Massachusetts, they were made by William Cranch Bond. Gilliss says:

> From that time (Sept., 1838) till the return of the expedition in 1842, I observed every culmination of the moon and every occultation visible in Washington which occurred between two hours before sunset and two hours after sunrise.
>
> The number of transits recorded exceeds 10,000 embracing the moon, planets, and 1,100 stars. The average annual number of culminations of the moon observed was 110 and of lunar occultations about 20.

An Act of Congress, August 31, 1842, authorized the erection of a permanent Depot of Charts and Instruments for the navy at a cost of $25,000 or less. It was finished in 1844 and the books, charts, and instruments were removed to the new quarters. The Depot soon became known as the U. S. Naval Observatory. This was the early location of the Naval Observatory at 23rd and D Streets N. W., where the U. S. Naval Hospital now stands. The present location was selected in 1881.

The little observatory on Capitol Hill, spoken of in one place as a temporary shed having a modest transit instrument, passed out of ex-

istence in 1842. It had lasted about ten years. Here Lieutenant Wilkes and Lieutenant Gilliss had made literally thousands of excellent observations. It was rather a flimsy building. The story goes that severe storms often blew off the shutters and doors so that the instruments were exposed. But yet it was a regular astronomical observatory with the transit instrument permanently mounted and the observations were taken from inside through roof shutters. Of course it was used almost entirely for determining time and latitude and longitude.

The David Rittenhouse Observatories

The paternal ancestor of David Rittenhouse came from Arnheim on the Rhine. David, the eldest son of ten children, was born in Roxborough, Philadalphia County, Pennsylvania, April 8, 1732. When he was two years old the family moved to Norriton, about 20 miles northwest of Philadelphia and engaged in farming. When twelve years of age he received a bequest of tools and mathematical books from his uncle David and this seems to have turned him definitely towards mathematics, mechanics, and astronomy. In 1749, when seventeen years of age, he gained the reluctant consent of his father to abandon farming. He soon built a small shop on his father's land beside the public road and began his career as clockmaker. About 40 clocks of his manufacture are in existence and some of them are magnificent ones. He also made two famous orreries, surveying instruments, and astronomical instruments. He was a skilled surveyor and did some preliminary work with his own instruments for the Mason and Dixon line in 1763.

In 1770, David Rittenhouse moved to Philadelphia and lived at the southeast corner of Seventh and Arch Streets. He was elected Secretary of the American Philosophical Society in 1771, Vice-President in 1790, and President in 1791. From 1779 to 1782 he was professor of Astronomy and Vice Provost of the University of Pennsylvania. He was Treasurer of Pennsylvania from 1777 to 1789 and the first director of the U. S. Mint 1792 to 1795. He died on June 26, 1796.

On June 3, 1769, occurred the famous transit of Venus. The previous transit in 1761 had not been as favorable and was not as widely observed. The American Philosophical Society was then in existence and appointed a committee of thirteen to observe the rare occurrence. They were divided into three groups. One group under the leadership of Mr. Owen Biddle observed near the lighthouse at Cape Henlopen on Delaware Bay. Another group under the leadership of Dr. John Ewing observed in Philadelphia near the State House. The third and most important group, of which David Rittenhouse was a member, observed at Norriton. Each group erected a temporary observatory. The one in Philadelphia was said to have been an uncovered raised wooden platform. The observatory at Norriton which is spoken of as a log-observatory, was commenced in November, 1768, and finished in April, 1769. A full account is given in Volume 7 of the *Transactions of the American*

Philosophical Society. Here the building of the observatory is described and the instruments used are fully listed. The observations were so excellent that combined with the observations at Greenwich a fairly accurate value of the solar parallax, and thus the distance of the sun, was determined.

In 1770, Rittenhouse moved to Philadelphia and the Norriton Observatory was soon after dismantled. It thus lasted but three or four years and was clearly only a temporary observatory erected for practically just one purpose, namely to observe the transit of Venus. Rittenhouse located on the southeast corner of Seventh and Arch Streets in Philadelphia. On the northwest corner, diagonally opposite, he eventually erected a small but convenient octagonal brick observatory. This was before 1786, since in that year he constructed his new residence near the observatory which he occupied for the rest of his life. In this observatory some of his instruments were installed and he made general observations which were published. The building of this observatory was partly financed by a grant from the Assembly. At first he used a 1200 foot meridian mark with the transit instrument. After a time other buildings gradually surrounded the observatory so that the meridian mark could not be observed. To obviate this difficulty he invented the use of a collimating telescope. When Rittenhouse died in 1796 he was buried under his observatory.

On June 27, 1796, Moreau de Saint Mory writes:

> Yesterday I attended the funeral rites here of the celebrated Dr. Rittenhouse, American astronomer whose loss his country most justly mourns. He was buried in the floor of the Observatory which he had had constructed in his own Garden. What a philosophic union, perishable ashes with an edifice consecrated to the observation of the most sublime marvels of nature! What a reproachment between the genius of man and his nothingness!

Later his body was removed to old Pine Street and at present his remains rest in North Laurel Hill Cemetery. This observatory, which had lasted more than ten years, was no longer used and was eventually dismantled.

William Cranch Bond's Observatory

William Cranch Bond was born in Falmouth, now Portland, Maine, on September 9, 1789. His father, William Bond, was engaged in the export of lumber but this did not prove successful so he moved to Boston and returned to his trade of silversmith and clockmaker at the corner of Milk and Washington Streets. Young William was obliged to leave the public school early to help earn the family living by working with his father. It is related of him that at the age of ten he made a crude clock with wooden works. At the age of fifteen he made a chronometer driven by a weight which was reasonably accurate. For a number of years before 1812 the errors and rates of nearly all of the chronometers of the ships out of the port of Boston were determined by him. In 1812, when twenty-three years of age, he made what was perhaps the first

regular chronometer made in America. Chronometers could not then, on account of the war, be procured from England. This chronometer was thoroughly tested by a voyage to Sumatra and return in the ship *Cyrus,* commanded by Captain Thomas B. Curtiss. It is still in existence and in the possession of the Bond family.

The first transit instrument used at Dorchester was a strip of brass nailed to the east end of the Champney house, with a hole in it to see a fixed star and note its transit. This was in 1813. Previous to this, time for rating the chronometers had been determined by sextant observations. Bond was married July 18, 1819, and a few years later he purchased a house near his father's residence in Dorchester. In connection with it he erected a small wooden building and equipped it with astronomical and meteorological instruments. The only parlor in the house at Dorchester was sacrificed to science—a huge, granite block rose in the middle of the room and the ceiling was intersected by an opening in the meridian. Such was Bond's Dorchester Observatory. Here he did constant work on the rates of chronometers and he made meteorological and magnetic observations as well. He was a constant observer of the heavens for the sheer love of it. Even his children were impressed into service as observers and recorders. And all the while he was earning his living by making, repairing, and rating chronometers and watches.

In 1838 when Captain Wilkes took charge of the exploring expedition to the South Seas, William Cranch Bond made observations under an appointment and contract with the Government of the United States of the moon culminating stars, of occultations of stars by the moon, and of other celestial phenomena for the better determination of his longitude. He was then spoken of as a skillful, accurate, and attentive observer. Bond immediately erected a new observatory of ample size in Dorchester and here and later at Dana House he observed from 1838 to 1842.

Professor Rufus in his article on "Astronomical Observatories in the United States Prior to 1848" in Vol. XIX of the *Scientific Monthly,* defines an early astronomical observatory as a tube with an eye at one end and a star at the other. If one accepts this fanciful definition of an observatory then Harvard College possessed a very early observatory. John Winthrop, who was born December 19, 1714, was made Hollis Professor of Mathematics and Natural History in 1738. In 1739 he made observations of sunspots which were published. On April 27, 1740, he observed a transit of Mercury. In 1761 he went to Newfoundland to observe a transit of Venus. In 1769 he observed the transit of Venus at Cambridge. In this instance, so the story goes, rather slow-going Philadelphia got the better of Cambridge. Professor Winthrop was to have a new telescope to observe the transit. It was shipped on a vessel going to Philadelphia and arrived only a few days before the transit. Knowing that it could not reach Boston in time, it was unpacked and used in Philadelphia and then sent on to Boston. In 1780 an expedition to observe a total eclipse of the sun was sent to Penobscot

Bay. A more correct statement would thus be that Harvard College possessed astronomical instruments from an early date but no astronomical observatory. The Harvard College Observatory was finally established by an official act of the Corporation of Harvard University in October, 1839. Harvard officials raised $3000 to adapt Dana House as an observatory. Bond was persuaded to become the first director without salary and he added his instruments to those owned by the college. The last Dorchester observation was made on December 25, 1839, and the first Cambridge observation was made December 31, 1839. Josiah Quincy, President of Harvard University, in his *History of Harvard University,* published in 1840, enumerates the available instruments.

> The observatory has now at its command, from the college apparatus and the instruments belonging to Mr. Bond, a transit instrument and variation transit, by Troughton and Symms; an astronomical clock, one refracting and two reflecting telescopes; an astronomical quadrant by Bird; Gauss' magnetometer; a small transit by Bird; a quadrant and sextant, with chronometers, thermometers, barometers, hygrometers, dipping and variation needles. To render the observatory as efficient as could be desired, there is wanted a refracting telescope equatorially mounted, a mural circle, and a large transit instrument.

Dana House was a large and substantial building situated on the southeast corner of the college grounds, having Harvard Street on the south and Quincy Street on the east. Although changed to become an observatory, it was also to be the residence of the Bond family. A cupola with a turning roof was erected on the top of the house. A large reflector belonging to the college and made by Short of London was mounted here. The transit instrument was placed in a building near by. One room of the house contained the clocks, chronometers, standard barometer and other apparatus. Another building contained the magnetic instruments. Dana House continued to be the Observatory of Harvard University for about four years when the present location was chosen. William Cranch Bond continued director of the Observatory of Harvard University until his death on January 29, 1859.

The Observatory of the College of William and Mary

The College of William and Mary apparently possessed an astronomical observatory at a very early date, at least prior to 1789. In Vol. 3, page 150, of the *Transactions of the American Philosophical Society* occurs the following:

> Astronomical Observations, communicated by David Rittenhouse
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> Observations of a lunar eclipse Nov. 2d, 1789, and of the transit of Mercury over the sun's disk. Nov. 5th the same year, made at the University of William and Mary, by the Rev'd Dr. James Madison.
> Read Feb.)
> 4th. 1791)
>
> As the observatory in which the transit instrument had been formerly placed, was not, at this time, rebuilt, I was not enabled to attend to the going of the time-keeper, by means of such observations as I wished to have made. I therefore had recourse to correspondent double altitudes, taken with a sextant.

It is supposed that Bishop Madison had very good scientific equipment for the time until the Yorktown campaign of 1781. The British soldiers at first occupied some of the college buildings and later the French soldiers. It may have been then that the observatory was destroyed.

Dr. James Madison was born August 27, 1749, near Staunton, Virginia. He was graduated from the College of William and Mary in 1771 and in 1773 he was made professor of natural philosophy and mathematics. In 1777 he was made President and continued in office until his death on March 6, 1812. He was a man of strong scientific inclinations and was spoken of as a man of note among the scientific men of his day. He was also a surveyor and thoroughly familiar with astronomical instruments. A few extracts from old letters will illustrate this.

From a letter dated July 26, 1778, telling of a solar eclipse: "I had the time very accurate."

From a letter dated 1780: "Our longitude may be seen from the following observations this summer. . . . The observations were made with a Reflector by Short, magnifying 200 —Time obtained by = altitudes. We have an excellent Time Keeper."

From a letter dated December 2, 1783, by J. Madison, Robert Andrews, and John Page to Governor Benjamin Harrison in regard to surveying the Virginia-Pennsylvania boundary:

> We have considered the Instruments which will be necessary for us in fixing the Boundary of Virginia & Pennsylvania, & find so great a Deficiency in this state that unless Instruments of the Value of about £135 Sterling can be procured which we think will most easily be done by Importation, the Business can not be accomplished with any Degree of Accuracy. The Observatories, which must be built at each Extremity of the Line, will, we suppose cost one hundred Pounds currency . . .

From a letter dated April 10, 1785:

> We were engaged last year in determining the 5 Degrees of Longitude claimed by Pennsa. and I believe few points in the globe are better ascertained. Our instruments were good. The timepiece I carried from this place exceeded even Mr. Rittenhouse's.

Yale Observatory

In 1828 Mr. Sheldon Clark donated the sum of $1200 to Yale University for the purchase of a telescope. It was procured from Dolland of London and arrived in 1830. It was five inches in diameter, had a focal length of 10 feet, and was provided with a spider line micrometer. This instrument was much larger than any telescope then in the country. It was declared by the maker to be: "perfect and such an instrument as he was pleased to send as a specimen of his powers." The telescope had an altitude and azimuth mounting and was placed in the Athenaeum Tower. It was mounted on castors and pushed about from one window to another. The windows were low and no object more than 30 degrees above the horizon could be observed. At the hands of Professor Denison Olmsted and Elias Loomis it was, however, put to good use. In 1835 Halley's comet was observed before news of its rediscovery

reached America. The teaching power of Professor Olmsted, the Dolland telescope, the meteor shower in 1833, and Halley's comet in 1835 aroused much astronomical enthusiasm at Yale. Professor Elias Loomis in his article on "Astronomical Observatories in the United States" in *Harper's New Monthly Magazine* for June, 1856, says: "A transit instrument of five feet focal length and four inches aperture has recently been presented to Yale College by Mr. William Hillhouse of New Haven; but for want of a suitable building for its reception this instrument has not yet been mounted." The Clark telescope thus seems to have been the only instrument in use for a long time. In fact it remained in the Athenaeum Tower for more than thirty years. It is now in the Franklin Institute in Philadelphia.

The Observatory of the University of North Carolina

Joseph Caldwell was born in Lamington, New Jersey, on April 21, 1773. He was a Princeton graduate in the class of 1791 when only 18 years of age and in 1795 was made tutor in mathematics at Princeton. In 1796 he was called to the University of North Carolina as professor. The University had then been opened but one year. In 1804 he was elected President and continued in office until his death on January 27, 1835.

In 1824, when the institution was in somewhat better financial condition, President Caldwell was given $6,000 by the trustees and went to Europe to purchase books and scientific apparatus. Having always been fond of the science of astronomy he spent quite a large part of this sum for astronomical instruments. These were a meridian transit telescope made by Simms, of London; an altitude and azimuth telescope also made by Simms; a telescope for observation on the earth and sky, made by Dolland, of London; and an astronomical clock with a mercurial pendulum, made by Molineux, of London. To these stationary instruments were added a sextant, made by Wilkinson, of London; a portable reflecting circle, made by Harris, of London; and a Hadley's quadrant. Of these the altitude and azimuth telescope was particularly fine. The horizontal and vertical circles were twenty and twenty-four inches in diameter respectively. Two verniers and reading microscopes were provided for each circle and they were graduated to five minutes of arc on platinum bands. These instruments were stored in the University buildings and used in the open or on the roof of the President's house until 1831. It is said that a platform had been placed on the roof of the President's house chiefly for naked-eye observations and instruction. An observatory was erected largely at President Caldwell's expense in 1830 and 1831. Its cost was $430.29½, and it was placed on the highest summit of a hill north of the Raleigh road near the village graveyard. It was of brick and stone construction about 20 feet square and 25 feet high (15 by 25 according to one account), without portico or entry hall. A well-constructed pier furnished a stable foundation for the transit in-

strument. The flat roof contained a wide slit which continued for some distance down the walls and afforded a range of 120° for the transit instrument.

Another pier rose through the roof and was capped with a circular disc of sandstone. On this was placed the altazimuth instrument. It is said that it was covered with a wooden cover which could be drawn aside when it was in use. Professor Caldwell was assisted in his observations by Professors Mitchell and Phillips and their first work was to find the approximate value of the longitude and latitude of the building in which they worked. The roof soon gave trouble and leaked so badly that even before the death of President Caldwell in 1835 the instruments had to be removed. After his death the building went rapidly to decay. It was partially burned in 1838. The fire is said to have been set by some students. Later the bricks which were good were appropriated by President Swain, Caldwell's successor, to build a kitchen. After 1838 observations were, however, continued by Dr. Elisha Mitchell in the attic of the large wooden building which he used as a chemical and metallurgical laboratory. In each end of the attic were two large windows, and in the roof eight others, four on either side. These observations were continued until the summer of 1857.

Eventually the instruments were permanently laid aside. It is said that Sherman's soldiers found that the tube of the old telescope on a dusty shelf had been selected by some of the professors as the safest hiding place for their watches and other valuable possessions. They underestimated the keen-eyed seekers for hidden valuables for they were discovered. According to the story, however, the commanding officer was in love with the President's daughter and forced the lucky soldiers to return their find.

A somewhat different version of the building of the observatory is given by Collier Cobb in *Popular Science Monthly*, October, 1896, pp. 763-771:

> Before the completion of the observatory building the clock and meridian transit were set up and used in the library of the University which was also Prof. Caldwell's lecture room. Here began in 1825 the first systematic observations upon the heavens made in the United States.

According to Mr. Cobb the observatory was finished in 1827 and in this observatory he placed the instruments which he had procured in Europe. A picture of the observatory accompanies the article.

The meridian transit could hardly have been set up and used in President Caldwell's lecture room. Roof slits and slits in the walls facing the north and south would have been necessary and that would have required the reconstruction of the whole room. Presumably this was simply a repository for the apparatus which was used in the open. The building pictured has a steep roof and no slits of any kind. It could hardly have been an observatory. Perhaps this was the library and lecture room which has been mentioned. A building corresponding to the

description of the observatory would have had an entirely different appearance.

The Wesleyan Observatory

Carl F. Price in his book *Wesleyan's First Century*, published by Wesleyan University, Middletown, Connecticut, in 1932, has this to say about the first observatory on page 40:

> In 1838-39 a small octagonal white wooden building was erected as an astronomical observatory on Cross Street in the rear of Professor A. W. Smith's house (later Professor Rice's). It was nine feet in diameter. In 1854 it was moved to the spot where the southwest corner of Rich Hall stood in 1868, when it had a somewhat ignominious fate for so important a window to the nightly heavens: a certain Mr. Tuit thereafter removed it to Indian Hill and used it as a hen-house (from Astronomy to Poultry!).

The second observatory was built in 1868 to house the Alvan Clark 12-inch refractor. It was cylindrical in shape and mounted on a tower attached to one of the dormitories and called Observatory Hall.

The fine Van Vleck Observatory is the third and present one. It was commenced in 1914, used for classes in 1915, and dedicated at Commencement, 1916.

Some claim that the first observatory dates from 1836. The University possessed at that time a 6-inch refractor by Lerebours, of Paris. This was purchased in the early part of 1836 and was tested by Arago at the Paris Observatory. His certificate of test is dated April 28, 1836. There is no certain record as to where or when it was set up. Wesleyan was founded in 1831 and the first president, Willbur Fisk, was in Europe during the academic year 1835-36 to procure philosophical apparatus.

The Observatory of Western Reserve College at Hudson, Ohio

Elias Loomis was born in the little hamlet of Willington, Connecticut, on August 7, 1811. He was graduated from Yale in the class of 1830. He entered Andover Theological Seminary in 1831 and in 1833 was called to Yale where he taught Latin, Mathematics, and Natural Philosophy. He was always very much interested in Astronomy, Terrestrial Magnetism, and Meteorology. With Denison Olmsted in 1835 he rediscovered Halley's comet before news of it arrived from Europe. In 1836 he was appointed Professor of Mathematics and Natural Philosophy at Western Reserve College at Hudson, Ohio. He studied in Europe from 1836 to 1837 before taking up his duties at Western Reserve. Considerable scientific apparatus including the outfit for a small observatory was procured during his stay in Europe. He returned in 1837 and remained at Western Reserve until 1844. From 1844 to 1860 he was Professor of Mathematics and Natural Philosophy at the University of the City of New York. In 1860 he returned to Yale and remained there until his death on August 15, 1889. He is chiefly known

as the writer of many textbooks on Mathematics, Astronomy, and Meteorology.

Harper's New Monthly Magazine for June, 1856, contains an article (pages 25-52) by Elias Loomis, LL.D., on: "Astronomical Observatories in the United States." Here are his own words about the observatory at Hudson, Ohio:

HUDSON OBSERVATORY, OHIO

The next experiment for an observatory was made in Ohio, in connection with the Western Reserve College. Having been elected to the Professorship of Mathematics and Astronomy in this institution in the spring of 1836, the writer was sent to Europe for the purchase of instruments and books, and returned in the autumn of 1837 with an equatorial telescope, a transit circle, and a clock. During the next season a building was erected, which, though quite moderate in dimensions, was well suited to the accommodation of the instruments. The entire length of the building is 37 feet, and its breadth 16 feet. The transit room is 10 feet by 12 upon the inside, having a sandstone pier in its center. The pier is entirely detached from the building, and descends about six feet below the surface of the earth. The transit commands an unobstructed meridian from ninety degrees zenith distance on the south, to eighty-nine on the north.

The centre room is occupied by the equatorial. It is 14 feet square on the inside, and is surmounted by a revolving dome of nine feet internal diameter. The equatorial pier descends six feet below the surface of the ground, and, like the transit pier, has a slope of one inch to the foot.

The transit circle was made by Simms, of London. It has a telescope of 30 inches focal length, with an aperture of nearly three inches. The circle is 18 inches in diameter, graduated on platina to five minutes; and it has three reading microscopes, each measuring single seconds.

The equatorial telescope, made also by Simms, has a focal length of five and a half feet, with an aperture of about four inches. The hour circle is 12 inches in diameter, graduated to single minutes, and reads by two verniers to single seconds of time. The declination circle is also 12 inches in diameter, graduated to ten minutes, and reads by two verniers to ten seconds of arc.

The clock was made by Molineux, and has a mercurial pendulum. The instruments were first placed in the observatory September, 1838, and during the whole time of his residence in Ohio, the author pursued a systematic course of observations, as far as his engagements in the college would permit, and without the advantage of an assistant. Among these observations may be mentioned, 260 moon culminations for longitude, 69 culminations of Polaris for latitude, 16 occultations, 5 comets, with sufficient accuracy to afford a determination of their orbits, besides a great variety of other objects, for regulating the clock, etc.

THE OBSERVATORY OF MIAMI UNIVERSITY AT OXFORD, OHIO

The *Miami Student* for November, 1904, contains an article by Dr. Robert W. McFarland on "The Old Stone Pier." Dr. McFarland was for a time Professor of Mathematics in Ohio State University and for a time President of Miami University. This article was solicited by Dr. Clyde Fisher then editor of the *Miami Student* and now curator of the Hayden Planetarium in New York City.

The following material was taken from this article:

Forty or fifty yards southwestwardly from the south door of the main building, there is a stone pier, about three feet high and about two feet square. Almost every stranger who sees it, asks what it was for.

The old stone pier long bore on its northwest face this inscription:

Designed in
1834
And erected in
1838
By John Locke, M. D.

More than twenty years ago some vandal defaced the stone and partly destroyed the inscription. John Locke was professor in the Cincinnati College of Medicine. He had been on the first Geological Survey of Ohio and delivered some lectures on Geology while engaged on the astronomical pier. The small transit telescope still in the University had been purchased of the Cincinnati College in 1836. The pier was made to suit the cast iron frame which supports the transit while in use. One of the iron fastenings is still on the old pier. After the pier was put in place here, in the early part of 1838, a small frame house was put over it. But in the course of a year or two, some persons, more inclined to pranks than to study, tore the building down and scattered the lumber around. The transit was replaced in the college apparatus room, and the building was never restored.

Which Was the First Astronomical Observatory in America?

Referring to the Rittenhouse observatories:

Lelande in his *Astronomie* published in 1772 says, "In America, I know of no observatory but that of Mr. Rittenhouse at Philadelphia."

Stokley in his *Stars and Telescopes* published in 1936, says, "But this deserves to be called the first American Observatory."

Maurice J. Babb in *Who was David Rittenhouse,* Leaflet 7, of the Rittenhouse Astronomical Society says, "This, the first and for many years the only observatory in the United States . . ."

Goode in *Report of the Smithsonian Institution* 412, 1897, says, "His observatory built at Norriton in preparation of the transit of Venus in 1769 seems to have been the first in America."

Referring to the Yale observatory:

Pendray in his *Men, Mirrors, and Stars,* published in 1935, says, "Yale University Observatory may therefore assuredly lay claim to being the first permanent observatory in America."

Referring to the Observatory of the University of North Carolina:

Dictionary of American Biography (in connection with Joseph Caldwell) says, "This was the first observatory established in connection with any educational institution in the United States."

Collier Cobb in "Some Beginnings in Science" in *Popular Science Monthly,* October, 1896, says, "But its interest for us today lies in the fact that it led to the establishment of the first astronomical observatory in the United States."

The *Encyclopaedia Britannica* in the article on observatories (14th edition) says, "The first American observatory is said to have been erected at Chapel Hill (N. C.) in 1831-32."

Referring to the Hopkins Observatory of Williams College:

Elias Loomis in "Astronomical Observatories in the United States" in *Harper's New Monhtly Magazine,* June, 1856, says, "The first attempt

to found a regular astronomical observatory in this country was made in connection with Williams College, Massachusetts, by Professor Albert Hopkins."

André, C. et Angot, A. in *L'Astronomie Pratique et Les Observatoires en Europe et en Amérique* say, "Le premier établissement des États-Unis qui mérita réellement le nom observatoire, celue du collége Williams, à Williamstown, dans l'État de Massachusetts, a été fondé en 1836 par le Professor Hopkins."

A correspondent of the London *Athenaeum* writing from Boston in May, 1840, says, "The facts are these: They have a small observatory in process of erection at Tuscaloosa, Alabama, for the use of the university in that place. Professor Hopkins of Williams College, Massachusetts, has a little establishment of the sort, and this is almost all in that State—all in New England! The only other establishment in the United States, known to me, is that in the Western Reserve College, Ohio, under the charge of Professor Loomis."

Consideration has been given to all *observatories* and not to *astronomical observations* made with instruments used in the open. Many astronomical instruments were in the possession of individuals and institutions even before 1600. Another article of even greater length could be written on all publishel astronomical observations made in America before 1840; the instrument used, the method of making the observation, and the accuracy.

Summary

Eleven observatories have been considered. The list includes all fully erected and equipped before 1840. Two of them were private observatories. One was a private observatory which developed into one owned by the United States Government. Eight were erected by educational institutions. These were:

The David Rittenhouse Observatories at Norriton from 1769 and at Philadelphia from before 1786 to 1796.

The Observatory of the College of William and Mary before 1789.

William Cranch Bond's Observatory at Dorchester from 1823 to 1839.

Yale Observatory in the Athenaeum Tower from 1830.

The Observatory of the University of North Carolina at Chapel Hill, North Carolina, from 1831 to 1838.

The private Observatory of Wilkes and Gilliss or the Depot of Charts and Instruments at Washington from 1833 to 1842.

The Observatory of Wesleyan University at Middletown, Connecticut, from 1836.

The Hopkins Observatory of Williams College from 1838 on.

The Observatory of Western Reserve College at Hudson, Ohio, from 1838 on.

The Observatory of Miami University at Oxford, Ohio, 1838 to 1840.

Harvard College Observatory at Dana House from 1839 on.

All of these were temporary or makeshift observatories or of fairly

short duration with the exception of two. These are the Hopkins Observatory of Williams College and the Observatory of Western Reserve College (or Western Reserve Academy as it is now called) which followed it by less than a year. Both of these are still in existence in essentially their original condition. The Hopkins Observatory of Williams College is thus the oldest extant Astronomical Observatory in America. The reader is left to judge which was the first Astronomical Observatory in America.

Classification of Solar and Lunar Eclipses

By ALEXANDER POGO

I

Penumbral and umbral eclipses; position of the new and of the full moon with respect to the ecliptic limits.

Lack of familiarity with the fundamental properties of solar and lunar saros series[1] in general, and an unscientific discrimination against penumbral lunar eclipses in particular, are responsible for a considerable amount of wrong or misleading information offered by the best astronomical textbooks and by works on total solar eclipses. The neglect of penumbral lunar eclipses renders, moreover, incomplete and unsuitable

TABLE I

CLASSIFICATION OF SOLAR AND LUNAR ECLIPSES

	Solar	Lunar
Penumbral	(p) partial, invisible p partial	(a) penumbral, invisible a appulse
Umbral	non-central: (t) } total, (at) } annular-total, (a) } annular central: t, at, a	p partial t total

for statistical investigations Oppolzer's lunar canon and the eclipse data in nautical almanacs. Table I gives a synopsis of the classification discussed in this paper.

Figure 1 indicates, schematically, the position, with respect to the node, of the first penumbral (P′), the first umbral (U′), the last umbral (U″), and the last penumbral (P″) eclipse of a solar or of a lunar saros

[1] A saros series is a sequence of eclipses occurring, at the same node, under gradually changing circumstances, at intervals of 6585.3 days.

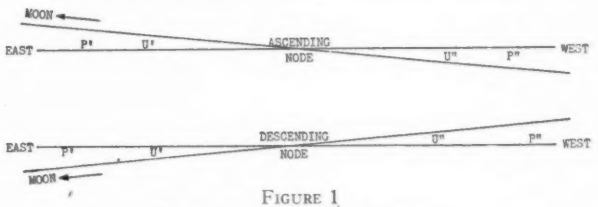

FIGURE 1
SOLAR AND LUNAR SAROS SERIES
P′ first penumbral eclipse
U′ first umbral eclipse
U″ last umbral eclipse
P″ last penumbral eclipse

series; in a given saros series, the exact distance of these four eclipses from the node depends on the corresponding positions of the earth and of the moon in their respective orbits and on the mutual inclination of these orbits.

Figure 2 shows, schematically, the position, with respect to the node, of the major and minor penumbral limits and of the major and minor

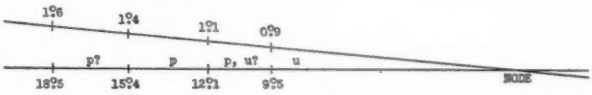

FIGURE 2
PENUMBRAL AND UMBRAL LIMITS OF SOLAR AND LUNAR ECLIPSES
p? penumbral eclipse possible
p penumbral eclipse certain
u? umbral eclipse possible
u umbral eclipse certain

umbral limits—both for solar and for lunar eclipses. When a conjunction in longitude of the sun and of the new moon—or the conjunction in longitude of the earth's shadow and of the full moon—occurs between the major and the minor penumbral ecliptic limits, a penumbral eclipse of the sun—or a penumbral eclipse of the moon—may take place; the corresponding latitude of the new moon—or of the full moon—varies from 1°.6 to 1°.4. When a conjunction in longitude of the sun and of the new moon, or an opposition in longitude of the sun and of the full moon, occurs between the minor penumbral and the major umbral ecliptic limits, a penumbral eclipse of the sun, or a penumbral eclipse of the moon, must take place; the corresponding latitude of the new or of the full moon varies between 1°.4 and 1°.1. When the new moon overtakes the sun—or when the full moon overtakes the earth's shadow—between the major and the minor umbral ecliptic limits, the resulting eclipse of the sun—or of the moon—will be at least penumbral, but an umbral eclipse is also possible; the corresponding latitude of the new moon—or of the full moon—ranges between 1°.1 and 0°.9. Finally, when the moon becomes new or full between the minor umbral ecliptic

limit and the node, an umbral eclipse of the sun or of the moon is inevitable; the corresponding latitude of the new or of the full moon is less than 0°.9.

The number of eclipses in a penumbral run preceding or following the umbral run of a saros series—and this applies both to solar and to lunar saros series—may vary between 6 and 25. The number of eclipses —either solar or lunar—in the umbral run of a saros series may vary between 39 and 59. The total number of eclipses, both penumbral and umbral, of a solar or of a lunar saros series may vary between 70 and 85. We see the complete analogy between the rôles played, in the saros series, by the penumbral solar and the penumbral lunar eclipses, on the one hand, and by the umbral solar and the umbral lunar eclipses, on the other. Statistical data found in the astronomical textbooks and in books on total solar eclipses are misleading or wrong: the authors ignore the existence of penumbral lunar eclipses and are satisfied with copying antiquated estimates made in the pre-Oppolzer era when statistical investigations of eclipses were practically impossible.

In the case of lunar eclipses, just as in the case of solar eclipses, there must be, during each eclipse season, at least one eclipse—either umbral or penumbral, and there may be two eclipses—both penumbral. Just as the number of solar eclipses within twelve consecutive months may be 2, 3, 4, or 5, the number of lunar eclipses occurring within a year may be 2, 3, 4, or 5. Just as there are calendar years with 5 penumbral solar and 2 umbral lunar eclipses, there are calendar years with 5 penumbral lunar and 2 umbral solar eclipses. The failure of the authors of textbooks to bring out these and similar analogies between the solar and the lunar eclipses is due, in part, to the fact that they restrict the use of the designation, "lunar eclipse," to umbral lunar eclipses; they prefer to perpetuate a distorted view of the beautiful eclipse mechanism rather than to change their habits of speech. Unscientific terminology is both a cause and a consequence of unscientific thinking.

Penumbral lunar eclipses constitute about 35.3 p.c. of all the lunar eclipses, just as penumbral solar eclipses constitute about 35.3 p.c. of all the solar eclipses. The average number, per century, of either lunar or solar penumbral eclipses is 84; the average number, per century, of either solar or lunar umbral eclipses is 154.

II

Penumbral solar eclipses invisible on account of the flattening of the terrestrial globe; position of the observer with respect to the surface of the penumbral cone.

The penumbral eclipses of the sun are usually designated as partial eclipses; we shall see, in chapter IV, that in the days of Oppolzer the "partial" solar eclipses included a small special group of umbral eclipses which happened to be non-central; although this error of classification has been corrected during the printing of Oppolzer's *Canon der*

Finsternisse (Vienna 1887), it is still customary to draw the dividing line between "partial" and "central" eclipses rather than between penumbral and umbral solar eclipses.

The penumbral eclipses of the sun are produced by the sweeping of the penumbral cone over the surface of the earth. In the beginning of the initial run and at the end of the terminal run of penumbral eclipses of a solar saros series, the penumbral cone can touch the earth in high latitudes only; it is, therefore, possible that some of these eclipses would be, theoretically, visible to an observer located on the surface of a spherical earth, but are, in reality, invisible to an observer located on our flattened globe; the surface of the oblique penumbral cone sweeps over his head, the limb of the moon fails to encroach on the edge of the solar disk, as seen from the surface of the earth.

These invisible penumbral eclipses of the sun constitute about 0.6 p.c. of all penumbral solar eclipses, or about 0.2 p.c. of all solar eclipses.

III

Total, annular-total, and annular eclipses of the sun; position of the apex of the umbral cone with respect to the surface of the earth.

The relative position of the umbral cone and of the surface of the earth leads us to two different classifications of umbral solar eclipses; in this chapter, the position of the apex of the umbral cone will be the criterion; in the next chapter, the influence of the position of the axis of the umbral cone will be discussed.

If, at the time of an umbral solar eclipse, the umbra is sufficiently long and the moon is sufficiently near, the apex of the umbral cone will reach the surface of the earth, and a total solar eclipse will take place; the total phase will, of course, be visible only to observers located within the tracks of totality, i.e., within the tip of the umbral cone.

If, at the time of an umbral solar eclipse, the length of the umbra and the distance of the moon completely prevent the apex of the umbral cone from reaching the surface of the earth, an annular eclipse of the sun will occur; the annular phase will be visible only to observers located within the tracks of the annulus, i.e., within the extension of the umbral cone beyond its apex.

If, at the time of an umbral solar eclipse, the length of the umbra and the distance of the moon are such that the apex of the umbral cone fails to reach the surface of the earth only during the beginning and the end —but not during the middle part—of the umbral phase, the resulting eclipse will be annular-total; the annular phases will be visible only to observers located within the initial and terminal tracks of the annulus, i.e., within the extension of the umbral cone beyond its apex; the total phase will be visible only to observers located within the tracks of totality, i.e., within the tip of the umbral cone.

It will be noticed that in classifying the umbral solar eclipses, with the position of the apex of the umbra as criterion, the question of centrality

did not arise. Textbooks fail to bring out this point. Any given umbral solar eclipse must, of course, be either total or annular-total or annular, and it must, at the same time, be either central or non-central; but the traditional way of referring to the group of total, annular-total, and annular eclipses as to "central" eclipses of the sun is objectionable, even though most total and annular eclipses, and practically all annular-total eclipses, are central. A far more objectionable abuse of the expression, "central," has arisen in connection with the purist tendency of avoiding the hyphenated adjective, annular-total. The *Nautical Almanac* designated the annular-total eclipse of 1890 December 12 as "total," adding an explanatory remark to the effect that the eclipse is scheduled to be annular near the times of beginning and ending; the *American Ephemeris* designated this eclipse as "central." The annular-total eclipse of 1908 December 23 was designated by the *N.A.* as "annular," and a note explained that the eclipse was scheduled to be total near the middle; the *Am. Eph.* designated the eclipse as "central." The annular-total eclipse of 1912 April 17 was designated as "central" both by the *N.A.* and by the *Am. Eph.*—independently from one another. The annular-total eclipse of 1930 April 28 was designated as "central" by the *Am. Eph.*, and, therefore, by the *N.A.* the eclipse section of which has been supplied from Washington. The semantic consequences of this official usage of the term, "central," in this special sense were quite unexpected. Those who sought to preserve the purity of their language by avoiding the term, annular-total, contributed, unwittingly, to the incorporation of a grotesque definition of "central" solar eclipses into one of the best dictionaries of the English language; this standard work of reference states that a solar eclipse may be "partial," "total," "annular," or "central," and its only definition of a "central" solar eclipse is as follows: ". . . central, when the moon is at the critical distance where its conical shadow, passing over the earth, falls short of certain regions (annular eclipse visible), but touches others (totality visible)."

Total eclipses of the sun constitute, according to the *Canon der Finsternisse*, 42.8 p.c. of all umbral solar eclipses; annular-total eclipses account for 6.8 p.c.; annular eclipses form 50.4 p.c. of all umbral eclipses. The apex of the umbral cone does, therefore, reach the surface of the earth in the case of 49.6 p.c., and fails to reach the earth in the case of 50.4 p.c. of all umbral solar eclipses; the apex of the umbral cone has, therefore, practically equal chances of reaching or of missing the surface of the earth during an umbral eclipse.

IV

Non-central umbral solar eclipses; position of the axis of the umbral cone with respect to the surface of the earth.

An umbral eclipse of the sun is central, if the axis of the umbral cone, i.e., the line joining the centers of the sun and of the moon, pierces the surface of the earth. It is obvious that if the altitude of the eclipsed

sun is low, a terrestrial observer may be within the umbral cone—or its extension beyond the apex,—while the axis of the cone fails to touch the earth; for this observer, the eclipse will be total—or annular,—without being central. A non-central total—or annular—phase occurs at the beginning and at the end of every central total—or annular-total or annular—eclipse of the sun, before the axis of the umbral cone reaches the terrestrial surface and again after the axis leaves the earth. Moreover, for an observer located within the tracks of totality or within the tracks of the annulus—but not on the central line, where the axis of the umbral cone pierces the earth,—the eclipse is total or annular without being central. Thus, there is nothing unusual in the observation of a non-central umbral phase of a solar eclipse; as a matter of fact, although central solar eclipses form a majority of the umbral solar eclipses, only a small minority of those observers who happened, in the course of the past millennia, to be located within the tracks of totality or of the annulus, have witnessed the central total or the central annular phase of a solar eclipse.

In the case of solar eclipses occurring, in the saros series, near the beginning or near the end of the umbral run, the oblique umbral cone or its extension beyond the apex may sweep the surface of the earth in higher latitudes without piercing it by the axis of the cones. Such eclipses of the sun are, of course, umbral without being central. In the days of Oppolzer, a solar eclipse had to be either "central" or "partial"; thus, in the manuscript of the *Canon der Finsternisse,* these transitional eclipses, which obviously were not central, were listed as partial; on the advice of Robert Schram, Oppolzer separated, during the early stages of the printing of the *Canon der Finsternisse,* these non-central eclipses from the ordinary "partial," i.e., from the penumbral eclipses. Oppolzer and Schram did not reclassify, explicitly, the solar eclipses into umbral and penumbral ones; they merely replaced the old distinction between

TABLE II

OPPOLZER'S ORIGINAL AND IMPROVED CLASSIFICATION OF SOLAR ECLIPSES

	Original	Improved
Penumbral	(p), p } partial	(p), p, (t), (at), (a) } non-central
Umbral	t, at, a } central	t, at, a } central

"central" and "partial" solar eclipses by a new one, between "central" and "non-central" eclipses; see Table II; the "non-central" eclipses included both the non-central umbral eclipses and the "partial," i.e., the penumbral ones. The importance of the Schram-Oppolzer last-minute correction is due to the fact that by separating the non-central umbral eclipses from the "partial" ones, they made, implicitly, the term "partial" interchangeable with our term, penumbral; similarly, by recognizing the existence of solar eclipses which were neither "partial" nor "central," they subdivided, implicitly, the umbral solar eclipses into central and non-central ones. The *Canon der Finsternisse* was published half a century ago, in 1887, yet the designation "central" is still widely used in the obsolete and unscientific manner, as an antonym for "partial" and as synonymous with "all total, annular-total, and annular" eclipses of the sun.

Non-central eclipses constitute about 1.3 p.c. of the umbral eclipses of the sun; almost 2 p.c. of all annular eclipses, and almost 1 p.c. of all total eclipses of the sun are non-central. The theoretically possible and exceedingly rare case of a non-central annular-total eclipse has eluded the computers of Oppolzer's 5147 umbral eclipses of the sun; in the case of such an eclipse, both the oblique umbra and its extension beyond the apex must come, in the course of the umbral phase, in contact with the terrestrial surface, yet the axis of the cones must not touch the earth.

Schroeter's *Spezieller Kanon der zentralen Sonnen- und Mondfinsternisse* (Kristiania 1923) offers a regrettable example of unjustified discrimination against non-central umbral eclipses of the sun. In his preface, he states that he omitted Oppolzer's annular eclipse of 1547 November 12, because his computations revealed that the eclipse was non-central; now, the tracks of the annulus crossed, according to Oppolzer, the British Isles and the Scandinavian countries; the presence or absence of a central line in the tracks of an annulus does not, of course, in the least affect the usefulness, both to the astronomers and to the historians, of an eclipse map; moreover, Schroeter's excellent maps show the northern and southern limits of the tracks, not the central line, so that the non-existence of a central line would not even have necessitated a departure from the adopted style of his maps; but Schroeter was a strict constructionist of the expression, "zentrale Sonnenfinsternisse," and he did not include the annular eclipse of 1547 November 12 in his *Spezieller Kanon.* We shall see, in chapter VI, that Schroeter construed rather loosely that curious designation, "zentrale Mondfinsternisse." It might be added, at this point, that Schroeter's contempt for solar eclipses which were not central led him, of course, to the exclusion of all the penumbral solar eclipses, although he took the trouble of computing and drawing the limits of the zones of conspicuous penumbral phases (down to magnitude 0.75) in the case of the central eclipses included in his *Spezieller Kanon;* now, penumbral solar eclipses often reach magnitudes between 0.75 and 1.00 in the latitudes of Europe, and

their intentional omission detracts from the usefulness to mediaevalists of Schroeter's *Spezieller Kanon.*

V

Penumbral lunar eclipses; position of the moon in the penumbral cone.

The existence of penumbral lunar eclipses is completely ignored by the best astronomical textbooks and by the computers of the canons. It is, however, implicitly recognized by such official publications as the nautical almanacs; in tabulating the circumstances of an umbral lunar eclipse, the almanacs give the time when the moon enters and leaves the penumbra, just as they indicate the time when the moon enters and leaves the umbra; the beginning and the end of the penumbral phase is quite unobservable, and, from a purely "practical"—as opposed to a scientific—point of view, their tabulation could be omitted. Occasionally, and somewhat inconsistently, not only the existence of the penumbral phases preceding and following umbral lunar eclipses, but even the existence of penumbral lunar eclipses is explicitly and officially recognized. Thus, the penumbral lunar eclipses of 1901 May 3 and of 1908 December 7 were listed in the *American Ephemeris,* in the *Nautical Almanac,* and in the *Connaissance des Temps;* the eclipse of 1890 June 3 was listed by the *Am. Eph.* but not by the other almanacs. Since all the inconspicuous penumbral solar eclipses visible in polar regions, and even the invisible penumbral solar eclipses have been computed and tabulated, there seems to be no valid reason why the easily computed penumbral lunar eclipses should be neglected. At least one out of four penumbral lunar eclipses is visible to the naked eye. The Maya table of ecliptic syzygies preserved in the Dresden Codex seems to indicate that the Maya observed, recorded, and predicted penumbral lunar eclipses along with the umbral ones; they had no means of distinguishing, on theoretical grounds, between the umbral and the penumbral eclipses of the moon; from the observational point of view, the difference between a small umbral and a deep penumbral eclipse of the moon is quantitative rather than qualitative.

Although references to "lunar appulses" in papers and books written in English are rather scarce, usage seems to have limited this expression to those penumbral lunar eclipses which are characterized by a close approach of the moon to the umbra; if the depth of immersion of the moon into the penumbral cone is insufficient to produce an observable darkening, the phenomenon ought to be designated, apparently, as a penumbral lunar eclipse rather than as a "lunar appulse." The *Nautical Almanac* seems to avoid the expression, "lunar appulse," and refers to a close approach of the moon to the umbra as a "penumbral eclipse of the moon." The vagueness of the extent to which a penumbral lunar eclipse may be designated as a "lunar appulse" would be a sufficient reason for avoiding the use of the term, "lunar appulse." As an additional reason we could quote the regrettable tendency of speaking of

"lunar appulses" as if they were not eclipses at all. A statement like "In the year —— there will be three eclipses, two of the sun and one of the moon, and a Lunar Appulse," when compared with a statement like "In the year —— there will be four eclipses, two of the sun and two of the moon, and a Transit of Mercury over the Sun's Disk," seems to suggest that "a Lunar Appulse" is something essentially different from a lunar eclipse, an extra added attraction like "a Transit of Mercury over the Sun's Disk." The French are free from this psychological handicap; the only way they can designate an immersion of the moon into the penumbral cone is to call it an "éclipse de lune par la pénombre," and this unmistakably acknowledges its claim to membership in the lunar eclipse family.

VI

Partial and total lunar eclipses; position of the moon in the umbral cone.

The umbral lunar eclipses are, traditionally, divided into partial and total eclipses; there is no analogy, except in the name, between partial lunar and partial solar eclipses, on the one hand, and between total lunar

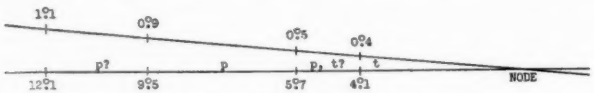

FIGURE 3

LIMITS OF UMBRAL LUNAR ECLIPSES

p? partial eclipse possible
p partial eclipse certain
t? total eclipse possible
t total eclipse certain

and total solar eclipses, on the other. Figure 3 indicates, schematically, the position, with respect to the node, of the major and minor umbral limits and of the major and minor limits of totality of lunar eclipses. When a conjunction in longitude of the umbra and of the full moon occurs between the major and the minor umbral ecliptic limits, a partial lunar eclipse may take place; the corresponding latitude of the full moon varies between 1°.1 and 0°.9. When the conjunction occurs between the minor umbral ecliptic limit and the major limit of totality, a partial lunar eclipse must take place, i.e., the limb of the moon must encroach on the umbra; the corresponding latitude of the full moon ranges between 0°.9 and 0°.5. When the full moon overtakes the umbra between the major and the minor limits of totality, the resulting lunar eclipse will be at least partial, but a total eclipse is also possible; the corresponding latitude of the full moon is between 0°.5 and 0°.4. Finally, when the full moon overtakes the umbra between the minor limit of totality and the node, a total eclipse of the moon is inevitable, i.e., the whole moon must pass through the umbral cone; the corresponding latitude of the full moon is less than 0°.4.

About 53.5 p.c. of the umbral lunar eclipses are partial, the remaining 46.5 p.c. being total. We have seen, in chapter I, that the number of eclipses in the umbral run of a lunar saros series varies between 39 and 59; the number of total lunar eclipses in such an umbral run may be as low as 11 or as high as 30; the runs of partial lunar eclipses which precede and follow the run of total eclipses may consist of from 6 to 23 eclipses.

We now come to the so-called "central" eclipses of the moon. Since the semidiameter of the cross section of the umbral cone at the moon's distance is always larger than the diameter of the moon, the moon may pass through the umbral cone without touching its axis; such eclipses occur at the beginning and at the end of the run of total eclipses of a lunar saros series. In the case of a majority of total lunar eclipses, the full moon will cross the axis of the umbral cone; such eclipses might be called "central," since the line joining the centers of the sun and of the earth pierces the moon; the duration of their total phase will be, in general, longer; a total eclipse may, however, last longer at apogee, without being "central," than some "central" eclipses last at perigee. Writers of textbooks and compilers of reference books who speak of "central" lunar eclipses never give a clear definition of this perfectly useless term. The real reason for the introduction of the objectionable and useless term, "central," into the classification of lunar eclipses, must have been the desire to complete the misleading analogy between the solar and the lunar terminology; since solar eclipses are, traditionally and unscientifically, subdivided into "central" and "partial" eclipses, it must have been tempting to subdivide the "lunar eclipses" (the umbral eclipses, of course, since the existence of the penumbral ones was ignored) into "central" and "partial" eclipses. The inclusion of all total lunar eclipses into the "central" group was the next inevitable step in this drive for uniformity, and a perfect example of the resulting confusion is offered by Schroeter's *Spezieller Kanon*. Both in the title of the work and in the preface, "zentrale Mondfinsternisse" are mentioned; no definition of the term is given, but other parts of the preface, the table of contents, and the lunar canon itself use the correct term, "totale Mondfinsternisse." Thus, to Schroeter, the strict constructionist of "zentrale Sonnenfinsternisse," the expressions "zentrale Mondfinsternisse" and "totale Mondfinsternisse" are synonymous. The useless and misleading term, "central," ought to be eliminated from the nomenclature of lunar eclipses.

Study 33, Deck A
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Washington, D. C.

Planet Notes for January, 1938

Note: All times unless otherwise stated, are Central Standard Time.

The *Sun* will move eastward from $18^h\,43^m$ to $20^h\,52^m$ and northward from $-23°\,4'$ to $-17°\,37'$ during this month. It will pass from the constellation Sagittarius into the constellation Capricornus through a region devoid of bright stars. The sun is closest to the earth on January 4 after which date it recedes during the rest of January.

The phases of the *Moon* for the month are as follows:

New Moon	Jan.	1 at	1 P.M.
First Quarter		9 "	8 A.M.
Full Moon		15 "	12 P.M.
Last Quarter		23 "	2 A.M.
New Moon		31 "	8 A.M.

The moon will be nearest the earth on January 15 and farthest from the earth on January 27.

Mercury will be moving westward among the stars until January 10. It will then move slowly eastward, the sun still moving away from it. As a consequence Mercury will be at a point of greatest elongation west of the sun on January 20. It will be accelerating its eastern motion and after January 20 will move eastward more rapidly than the sun. On and near January 20 this planet may be seen near the eastern horizon just before sunrise.

Venus will be near the sun and will keep pace with it in its eastward motion. Consequently this planet will be invisible during this month. By the end of the month it will be near superior conjunction.

Mars will move continuously eastward through about one and a half hours of right ascension. It will be visible in the evening sky throughout the month. It will cross the equator from south to north on the last day of the month.

Jupiter, like Venus, will be lost in the rays of the sun during January. It will be in conjunction with the sun on January 29. This means that on this date the sun will pass the planet as they move eastward together. The distance between Jupiter and the earth will be increasing.

Saturn will move eastward about two degrees during this period. It will be well situated for observation, being well up in the evening sky at sunset. It will be in the constellation Pisces.

Uranus will be in quadrature, 90° east of the sun, on January 30. Consequently it will be near the meridian at sunset throughout this period. It will be in Aries, a short distance west of the Pleiades.

Neptune will be observable only in the early morning. On January 15 its position will be R.A. $11^h\,29^m$, Decl. $+4°\,36'$, about twenty degrees southeast of Regulus.

Asteroid Notes

By HUGH S. RICE

Inasmuch as the "Big Four" asteroids—those numbered 1, 2, 3, and 4—are for the most part inconveniently placed for telescopic work this month, observers will concentrate on fainter ones, the best of which have their ephemerides given in the

November issue of this periodical. As 5 of them have magnitudes about 9, they are within range of small telescopes. Planet 39 Laetitia is well located in Orion, west of Betelgeuse, and when the moon is not in the way should be a good one for observation; similarly 349 Dembowska, near the Auriga-Perseus-Taurus boundary, should be picked up on a dark night by following the ephemeris given.

Eros

Several new books on astronomy still say that Eros comes nearer the earth than any other celestial object except the moon, whereas other minor planets—Adonis, Apollo, and Amor—all are now known to have parts of their orbits lying considerably closer to the earth. Moreover, it is known that meteors and comets' tails come much nearer to us than the moon. While Eros no longer has the record for nearness to the earth, it is probably as interesting to professional astronomers as the other minor planets mentioned, for so many observations have been made that a few definite facts on the physical nature of this body can be inferred. The asteroid has become so famous that owners of small telescopes take pleasure in finding and observing it. Like a faint comet within reach of the telescope but near the earth, it presents a kind of challenge to observation on account of its swift motion on the stellar background of the heavens. When near the earth, Eros has such a rapid motion that the latter can be detected in an hour, more or less, depending upon the magnification used. Around February 1 the movement in declination is over $1\frac{1}{2}°$ per day.

Photometric determinations have established the fact that the light of Eros fluctuates with a period of $5^h\,16^m$ [or 17^m], and this variation likely results from rotation of the planet. It is by a careful study of this phenomenon that several facts have been determined. The range of variation of magnitude is not constant, but varies with respect to the place of Eros on the celestial sphere. The maximum range is about 1.5 magnitudes. Variations in brightness, Watson of Harvard points out, which are due to differences in the surface of the asteroid, will be at a maximum when the earth is in the equatorial plane of Eros, and conversely a great number of observations of magnitude will establish the circle in the sky, which has for its pole the axis of rotation of the asteroid. This great circle is found to have its pole in R.A. $21^h\,4^m$, and Decl. $+51°$. The rotation of Eros is determined as retrograde.

The 1931 opposition was observed by van den Bos and Finsen, who report that Eros appeared with the form of a figure 8, and therefore looked like a close double star with a separation of 0".18. A double asteroid with components revolving around the common center of gravity has been suggested by several astronomers, but it is held that gravitational attraction between such small components would be so small that they would not hold together, and that if they had been originally separate planetoids they could never have been drawn together. Van den Bos and Finsen hold that the shape is probably not that of a double planet but an irregular solid, with length about 35 km [21.7 miles] and the other dimension 11 km [6.8 miles]. The axis of rotation is supposed by these astronomers to be at right angles to the greatest diameter. In other words the planet resembles a much-flattened oblate spheroid. The calculations of the dimensions are based on the distance mentioned, of 0".18, and the distance of the asteroid from the earth of 0.177 astronomical unit at the time. Watson points out that if this assumption of the length be correct, then on January 20, 1938, when Eros is 0.216 unit from the earth, the separation of the "components" should be 0".20. It will be interesting to have this checked by observation in very large telescopes. The inclination of

the equator of Eros to the ecliptic is probably 152°.5 or 146° to the plane of its own orbit around the sun.

On the basis of statistical work gathered by Watson, concerning the light variations with respect to the place in the sky and therefore the earth with respect to the pole of rotation of Eros, this investigator has drawn up a table of predicted ranges in magnitude variation during the coming apparition. The maximum range of 1.5 magnitudes occurs on February 5, 1938, and the minimum on March 31 or later. In October, 1937, when Meyer at Rutherford could find no apparent fluctuation in magnitude in several hours, the value predicted by Watson is only $0^{M}.5$.

We propose to publish in the January issue a chart of Eros covering the time of nearest approach to the earth. A single chart can cover but a small part of the apparent course during an apparition because of the rapid motion. The following ephemeris is by von Schelling in the *Astronomische Nachrichten;* the magnitude however is increased by 1.0 over von Schelling's, in conformity with recent observations mentioned.

EPHEMERIS OF 433 EROS. FOR 0^{h} U.T. EQUINOX OF 1937.

	α	δ	
	h m	° ′	Mag.
1937 Dec. 9	3 54.9	+60 54	9.2
13	3 51.1	59 48	9.1
17	3 48.6	58 21	9.0
21	3 47.7	56 32	8.9
25	3 48.4	54 23	8.8
29	3 50.8	51 55	8.7
1938 Jan. 2	3 54.9	49 10	8.7
6	4 0.4	46 11	8.6
10	4 7.3	43 0	8.6
14	4 15.4	39 40	8.6
18	4 24.3	+36 16	8.6

Hayden Planetarium, American Museum of Natural History,
New York City, November 20, 1937.

Occultation Predictions

(Taken from the *American Ephemeris*)

OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′.

Date 1938	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION a	IMMERSION b	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION a	EMERSION b	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
Jan. 3	27 G.Cap	6.2	21 9.9	−2.0	−2.3	114	21 58.0	+0.1	+1.6	195
7	BD−2°5858	6.4	0 29.1	−0.7	−0.2	59	1 34.9	−0.4	−0.7	249
8	19 Psc	5.3	0 37.6	−0.8	+0.8	36	1 38.5	−0.8	−1.6	273
12	ω Tau	4.8	19 56.5	−0.2	+1.0	101	20 48.3	−0.1	+1.9	235
12	224 B.Tau	6.1	22 7.3	−1.1	+0.8	103	23 8.9	−0.9	+2.0	234
12	227 B.Tau	5.9	22 39.8	−1.1	+1.4	81	23 50.4	−1.4	+1.2	257
14	ζ Tau	3.0	3 33.5	−1.5	−2.0	129	4 37.0	−1.9	+0.4	243
14	BD+20°1105	5.9	8 25.4	−0.1	−1.4	101	9 18.4	+0.2	−1.3	278
14	ν Gem	4.1	21 12.6	+0.4	+1.7	63	21 59.6	−0.3	+0.5	298
17	60 Cnc	5.7	9 4.6	−0.8	−1.7	121	10 7.3	−0.6	−1.7	289
19	237 B.Leo	6.3	13 0.8	−0.4	−0.6	59	13 35.5	0.0	−2.6	346
23	214 G.Vir	6.4	9 9.6	−1.0	−0.9	145	10 23.9	−2.3	+0.3	266

Occultations Visible in Longitude +91° 0′, Latitude +40° 0′.												
Jan.	7	BD—2°5858	6.4	0	10.4	—1.2	+0.6	49	1	23.9	—1.1	—0.6	252
	8	19 Psc	5.3	0	16.8	—0.9	+2.0	23	1	19.3	—1.8	—1.6	277
	12	224 B.Tau	6.1	21	51.9	—0.3	+1.3	87	22	50.8	—0.5	+1.6	248
	12	227 B.Tau	5.9	22	23.7	—0.3	+1.8	66	23	25.0	—0.9	+1.1	270
	14	ζ Tau	3.0	3	6.0	—2.0	—2.6	143	3	55.2	—2.0	+3.0	220
	14	BD+20°1105	5.9	8	26.0	—0.3	—2.0	128	9	18.4	—0.6	—0.8	253
	17	60 Cnc	5.7	8	54.6	—0.7	—2.5	153	9	51.9	—1.7	—0.8	261
	19	237 B.Leo	6.3	12	48.8	—1.0	—0.9	78	13	40.0	—0.3	—2.4	333
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′.													
Jan.	6	44 Aqr	5.8	3	37.1	—0.5	—0.2	60	4	40.2	—0.2	—0.5	249
	14	ζ Tau	3.0	2	15.9	—1.6	—0.7	132	3	2.5	—0.6	+3.0	219
	17	α Cnc	4.3	9	8.8	—2.1	—0.4	100	10	23.2	—1.3	—2.0	316
	17	κ Cnc	5.1	14	26.6	—0.2	—1.4	106	15	20.6	+0.1	—1.6	300
	19	237 B.Leo	6.3	12	10.6	—1.6	—1.5	122	13	27.8	—1.4	—1.8	300
	19	55 Leo	6.0	14	25.0	—1.3	—0.7	78	15	17.6	—0.4	—2.6	335
	23	40 H.Vir	5.1	11	15.2	—1.9	+1.4	86	12	25.9	—1.0	—1.3	328

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

To give some variety to these Notes and because it is of value to know what investigators are doing in other countries as well as our own, several Russian articles are reviewed, and one important American publication also. It is believed that few of our members ever see the Russian journals so that comments on the extremely important and extensive meteor work done there should be of interest. It is true that I am handicapped by not knowing the language but résumés in English, French, or German are often given, and the tabular matter and equations are usually intelligible, so at least the general line of argument can be followed.

There recently appeared in Vol. VII of *Publications de l'Observatoire Astronomique de l'Université de Leningrad*, pp. 76-102, one of the most important catalogues of meteor radiants ever published. Its title is "Revised Catalogue of 827 Meteor Radiants and Corresponding Orbits" by N. N. Sytinskaja. The actual observing was done between April, 1924, and November, 1931, at four stations in the U.S.S.R. The resulting 827 radiants are based upon 7399 meteors out of a total of 16,267 plotted in 905 hours work, which shows the high hourly rate of 18. This is partly explained by clear nights only being used, presumably with excellent conditions. An interesting thing to the writer of these Notes is to see that Sytinskaja not only adopted the general rules for determining radiants which are used in the A.M.S. but has made them even more rigid. Most of his radiants depend upon

many more than four meteors (his usual minimum), all observed on one night in less than four hours and none whose projected path is more than 2° from the radiant adopted. Apparently he, as I, has no belief in "radiants" deduced by any method whatsoever when the meteors which are supposed to belong to them deviate very widely from the adopted centers. From 38 years of personal experience in meteor observing, I know that for well-known showers, rich in meteors, such as the Perseids, Leonids, etc., while the radiants are certainly not "points" still their areas are small when one determines them from meteors marked on the records as "well observed." Therefore, when any observer or group of observers sends in maps, say of the Perseids, with meteors in large numbers whose projected paths miss the radiant by 5° to 15°, it is certain that the plotting is poor. No matter whether the observations are made using maps or reticles, if it becomes necessary to combine such projections into so-called "radiants" no amount of statistical work or least-squares solutions will remove the basic fact that the observations themselves are of inferior quality and hence the deductions therefrom most uncertain. What is true of the major streams will, in general, undoubtedly be true of the minor.

Returning to the article under review, the tabular matter contains 100 deduced orbits, from 4 Lyrid, 71 Perseid, 19 Pons-Winnecke, and 6 Leonid radiants, calculated as elliptic, and 727 others calculated as parabolic, no period being known. Among the former the most striking thing is the richness of the Pons-Winnecke stream in 1927 from June 17 to July 8. The maximum number of paths from a single radiant was 69 for June 26, but for June 25 and June 27 also 46 paths each were available. This relative richness was in striking contrast to the poor display seen in America that year, as we may assume it meant an hourly minimum rate of 15. The 4 Lyrid radiants show no certain shift. The Perseid radiants, however, indicate daily motion most beautifully, going from $\alpha = 21°.1$, $\delta = +46°.4$ on July 17.7 to $\alpha = 50°.2$, $\delta = +59°.4$ on August 17.9. The change for the 6 Leonid radiants seems consistent but small. Among the parabolic orbits are found 5 for the Orionids which show the shift first proved by me in 1911 for this stream. It is noted with satisfaction that no attempt is made to "name" the minor streams, save a single one denoted β Cass. This is first given for July 15.7 at $\alpha = 348°.9$, $\delta = +56°.8$ (15 meteors) and is last given for August 10.8 at $\alpha = 0°.9$, $\delta = +59°.4$ (11 meteors). In all, 44 of these radiants were found, the peculiar thing about their orbits being that they are nearly perpendicular to the ecliptic. A very hurried search through the A.M.S. card catalogue of radiants shows from 20 to 25 radiants in July and August, by our observers, which probably belong to this stream. It seems, therefore, that this may be accepted without reserve as a real stream. The "Remarks" in Sytinskaja's catalogue show that perhaps one quarter of the radiants therein are confirmed by others. As the data are based upon one man's work, the plans for which were carefully laid and carried out, the results derived therefrom have special value. It is a great pity that the publication, this particular section of which is in English, will not be more generally available. It is hoped that those of our members most seriously interested in the subject may be able to secure copies by writing directly to its author. Incidentally, on pages 71-72 of the same volume is another article by him: "On the Efficiency of Different Kinds of Lenses in Meteor Photography." This too has some interesting results based upon experiments with six lenses. The best rate he found was 1 meteor per 2.1 hours of exposure, this being with an Aviar lens, 1 : 4.5, F = 210 mm. Indeed these two papers are another proof of the great amount of valuable work being done at present in the U.S.S.R. in meteoric astronomy.

A paper which appeared some time ago (1932) as Bulletin 16 of the Society of Amateur Astronomers of Moscow, by K. Stanjukovitsch, merits attention. It is a method for determining the heights and geocentric velocities of meteors from observations at one station. Inherently it can only be accomplished by making certain assumptions. The paper itself is in Russian but there is a page résumé in German. Table II therein contains 80 meteors for which calculations were made, and the results certainly look probable. The six known quantities which have entered are: angular length of path, angular distance of radiant from beginning and from ending points of path, zenith distance of these points, and zenith distance of radiant. The brightness of the meteor is also reduced to what it would be in the zenith, and the linear length L of the path is derived considering it as a function of the duration and magnitude. Obviously then, only when the radiant is known, *i.e.* for the main showers, would the method be applicable. I tried to check the equations used but for the two in which ΔH occurs, there is either a misprint or original error, for the second is certainly impossible nor can it be derived from the first on any assumption whatever. Not reading Russian, I could not follow out the arguments, but as two others had already tried to solve this general problem, namely Hoffmeister and Stande, it seems wise to call it to the attenion of our readers as something which may have promise, at least statistically for the mean of large numbers of cases, if useless for individual meteors. There are two other papers in the same number on meteors but wholly in Russian. It is a great pity that what may be most valuable work is practically sealed to observers in other countries.

A paper entitled "Photograph of a Bright Meteor" by V. Fedynsky and K. Stanjukovitsch, published in March, 1935, in *Astronomical Journal of Soviet Union* XII, 5, has special interest because it contains results based upon simultaneous photographs taken at two stations, one of the cameras being equipped with a rotating sector. The meteor belonged to the well-known Cassiopeid radiant, being determined (after corrections) as at $\alpha = 21° 59'$, $\delta = +60° 18'$. The meteor, magnitude —2, appeared at 187 km and disappeared at 60 km, geocentric velocity 66 km/sec, all according to visual observations. The part of the trail photographed was 33.40 km long, the highest point being at 91.49 km, the lowest at 59.29 km. A table gives the geocentric velocity at different heights, this varies from 54.3 km/sec at H = 84.24 km to 36.7 km/sec at 61.02 km. It is calculated that the geocentric velocity beyond the atmosphere is 58.0 km/sec. From the data the authors derived tabular values for the retardations at different heights, its brightness on an arbitrary scale, and finally applied the results to a study of the upper atmosphere.

Coming to our country a publication of much value has just appeared. This is "Catalogue of the Meteorites in the American Museum of Natural History," by C. A. Reeds. This Bulletin is part of Vol. LXXIII of their publications. In it a brief history is given of the acquisition of the 548 catalogued falls and finds which make this collection one of the largest in the world. Included in it is a brief but interesting description of the finding of the Cape York meteorites and the Willamette meteorite, one of the former being the largest in any museum. On an average, there are six meteorites described on each page, there being given its name, when found or when it fell, class, size of specimen(s), and general remarks. Of the 548 specimens there are 282 aerolites, 238 siderites, and 28 siderolites. Two tables follow giving alphabetically the individual meteorites in the above three classes, and another table giving the falls by countries. Several pages are devoted to the Rose-Tschermak-Brezina system of meteorite classification, and finally over

a page of bibliography on the more important catalogues and publications. The information is all in the most compact and useful form and it is a publication that all our members would do well to acquire.

Flower Observatory, Upper Darby, Pennsylvania.

On Telescopic Magnitudes of Meteors

By C. C. WYLIE

For a slowly moving meteor the head may be seen as a definite point of light. For an occasional meteor the head is somewhat nebulous, so that it is magnified in the telescope and seen as a hazy ball rather than as a point of light. But the usual meteor is seen as a line of light. The head is too small to appear as other than a point, even in a telescope, and the angular velocity is too great for the head to be seen as a point. The rapidly moving point generates a line.

When the meteor can be seen as a point the apparent telescopic brightness should be calculated by the formula used for the apparent brightness of a star. When the head is seen as a hazy ball of light, the brightness should be calculated by the formula used for the apparent brightness of a surface. When, however, the meteor appears as a line, a different formula must be used. Let us consider the formulas for the point and the surface, and develop a formula for the line.

The Apparent Brightness of a Point

If a telescope is used to observe a star or other point of light, the apparent brightness is

$$B = kD^2 \qquad (1)$$

where B represents the brightness, k is a constant, and D is the diameter of the objective.

Let us assume that the pupil of the eye opens to a diameter d, and that 6th magnitude stars can be seen. Substituting in formula (1)

$$2.512^6 = kd^2$$

whence

$$\log k = 2.4 - 2 \log d$$

Substituting in formula (1) and solving

$$m = 6 - 5 \log d + 5 \log D \qquad (2)$$

where m is the magnitude of the faintest star seen. The loss of light in the optical system of the telescope is neglected. The formula gives the real apparent magnitude of stars whose apparent magnitude in the telescope is 6. These are the faintest visible in the telescope. By substituting the apparent magnitude of any other star as seen in the telescope for the "6" in the formula, the real apparent magnitude of that star can be calculated.

It has been assumed generally that the diameter of the pupil of the eye in relatively complete darkness is ¼ inch. However, motion picture studies at the Eastman Kodak Company, at the University of Iowa, and elsewhere, show the diameter to be about ⅓ inch under good conditions. Substituting the latter value for the d in formula (2) we obtain

$$m = 8.4 + 5 \log D \qquad (3)$$

For photographic work on stars the same relation holds. If the magnitude of the faintest stars photographed with a lens of a certain aperture and type is known,

the constant k in formula (1) can be evaluated, and the limiting magnitudes for other apertures determined.

The Apparent Brightness of a Surface

Let us now consider the apparent brightness of a nebula, or of a star cluster so distant that it appears as a surface rather than as a collection of points. The apparent brightness would increase as the square of the aperture, but it would decrease as the square of the magnification. Denoting the apparent brightness by B, the diameter of the objective by D, and the magnification by M, we have

$$B = kD^2/M^2 \tag{4}$$

From the above it is evident that to make the brightness as great as possible, the magnification should be as small as possible. Let us denote the diameter of the pupil of the eye in darkness by d, and the apparent brightness of the nebula, cluster, or other surface to the naked eye by b. For the naked eye $M = 1$. Substituting in (4) we obtain

$$b = kd^2$$

whence

$$k = b/d^2$$

The lowest magnification possible without loss of light, or the one which gives the maximum brightness is $M = D/d$. Substituting this value of M, and the above value of k in the general formula (4) we obtain a formula giving the maximum brightness of surfaces with various telescope apertures.

$$B = (b/d^2)\, D^2/(D^2/d^2) = b \tag{5}$$

The maximum apparent brightness, B, of a surface viewed with a telescope of aperture D is b, the apparent brightness of the same surface as viewed with the naked eye. The actual apparent brightness must be somewhat lower, because of loss of light, in the optical system. However, surfaces which are too small to be seen with the naked eye or with a small telescope may be enlarged to easy visibility in large telescopes.

Let us now consider the problem of photographing a surface, with a lens of aperture D, of focal length F, and of focal ratio $R = F/D$. The brightness of the image obviously varies as D^2. The size of the image varies as F^2, so the brightness must vary inversely as F^2. Hence

$$B = kD^2/F^2 = k/R^2 \tag{6}$$

This formula gives the well-known result that the speed of a lens for photography of surfaces varies with the focal ratio.

The Apparent Brightness of a Line

The brightness of a meteor seen as a line is obviously increased as the square of the aperture of the lens. Since it is magnified in one direction only, the brightness is decreased as the magnification. Using the previous notation

$$B = kD^2/M \tag{7}$$

Let us assume that for the naked eye $m = 5$, $D = d$, and $M = 1$. Substituting

$$2.512^5 = kd^2$$

whence

$$\log k = 2 - 2 \log d$$

Substituting in formula (7) we obtain

$$m = 5 - 5 \log d + 5 \log D - 2.5 \log M \tag{8}$$

This formula gives us the real apparent magnitude of meteors whose apparent magnitude in the telescope is 5. These are the faintest meteors visible. By substituting the apparent magnitude of any other meteor as seen in the telescope for the "5" in the formula the real apparent magnitude of the meteor can be calculated.

From formula (7) we see that the apparent brightness of a line meteor is greatest for the lowest magnification without loss of light. This is, as we have said, $M = D/d$. Substituting in (8) and evaluating for $d = \frac{1}{3}$ inch

$$m = 6.2 + 2.5 \log D \qquad (9)$$

Formula (9) gives the magnitude of the faintest line meteor visible under the best conditions in a telescope of aperture D.

Photography of Line Meteors

Let us assume that we are photographing meteors using a lens of aperture D and focal length F. Let us assume further that the image is a line. The intensity of the line is obviously proportional to the light received by the lens, or to D^2. The length of the line is increased, and consequently the intensity is decreased, with F. Hence for photography of meteors

$$B = kD^2/F \qquad (10)$$

If one knows the magnitude of the faintest meteors photographed with a given lens of aperture D and focal length F, the constant k can be solved for, and the result substituted in the general equation. The limiting magnitude for a similar meteor, with a similar lens of different aperture and focal length, can be calculated.

Estimating the Magnitudes of Telescopic Meteors

The naked-eye brightness of a star is, from formula (2), increased in a telescope by

$$\Delta m_1 = 5 \log D - 5 \log d$$

The naked-eye brightness of a meteor is, from formula (8), increased in a telescope by

$$\Delta m_2 = 5 \log D - 5 \log d - 2.5 \log M$$

whence

$$\Delta m_1 - \Delta m_2 = 2.5 \log M \qquad (11)$$

Formula (11) gives us a simple rule for obtaining the magnitude of a telescopic meteor as follows: Estimate the real apparent magnitude a star in the field should have to appear of the same brightness as the meteor. The real apparent magnitude of the meteor is brighter by the amount $\Delta m = 2.5 \log M$.

We have said before that the real apparent magnitude of a meteor could be calculated from the apparent magnitude as seen in the telescope using formula (8). That is, if a meteor in the telescope appears as bright as a 2nd magnitude meteor does to the naked eye, the real apparent magnitude of the meteor can be calculated by formula (8). However, it should be more accurate to compare the meteor with a star seen through the same optical system and calculate the real apparent magnitude of the meteor from formula (11) which gives the magnitude from the magnification only.

Summary

If the angular velocity of a meteor is small enough that the head is seen in the telescope as a definite point of light, the real apparent magnitude should be calculated from the formula for the apparent magnitude of a star seen in the telescope. If a slowly moving meteor has a nebulous head so that it is seen as a ball of light, the apparent surface brightness of the ball should be calculated from the

formula for a surface. If the meteor is seen as a line of light, the apparent brightness should be calculated from the formula for a line.

For a point of light the brightness depends only on the aperture of the telescope or camera. It is proportional to the square of the aperture. For a surface of appreciable area the apparent brightness cannot be greater than the apparent brightness of the same surface as seen with the naked eye. However, surfaces too small to be seen without a telescope may be enlarged in a telescope to easy visibility. The efficiency of a telescope in the photography of surfaces depends only on the focal ratio.

For a line of light the brightness is proportional to the square of the aperture and inversely proportional to the magnification used. In photography of meteors the intensity of the image is proportional to the square of the aperture and inversely proportional to the focal length of the lens. Hence it is desirable to have a lens of large aperture and short focal ratio. If a line meteor and a star of the same real brightness are seen together in a telescope, the star will appear M times as bright, where M is the magnification used.

University of Iowa, November 20, 1937.

Contributions of the Society for Research on Meteorites

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The Question of the Meteorite of June 30, 1908, in Central Siberia*

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On June 30, 1908, at 7:00 A.M., in mild weather and a cloudless sky, a large bolide or fireball rushed along in the general direction from south to north over the basin of the River Yenissei in central Siberia. The fall of the mass onto the earth was completed by the appearance of a column of fire raised over the taiga [virgin forest]—and observed from a distance of 400 km. at Kirensk—by three or four powerful thunderclaps and a crash, recorded at a distance of more than a thousand kilometers from the center of the fall, and by powerful air waves. To distances of some scores of kilometers around the center of the fall, these waves blew down the trees of the taiga in an eccentric-radial direction, tops outward, and were so powerful that they set into motion the baromicrographs of western Europe as well as those of North America and other countries. These waves went around the world and were recorded a second time in Potsdam, Germany. Seismographs all over the world (at such widely separated stations as, *e.g.*, Irkutsk,

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[Since English is not the native language of the author of this paper, it has—as regards diction only—been very freely edited. Words inclosed in square brackets have been inserted by the Editor.]

Tashkent, Tbilissi, Jena, Washington, and Java) recorded powerful earth waves, which, as just stated, twice encircled the globe, as a result of the explosive action of the meteorite on the earth's crust. The epicenter of this disturbance was located behind [the] Podkamennaya Tunguska, in the region of the factory [of] Vanovara. Huge masses of the finest substance, sprayed by the meteorite in its flight through the atmosphere and raised by the explosion in the earth's crust (due to the cosmic speed of the impact of the meteorite), caused the heavy blanket of dust in the upper layers of the atmosphere, and the formation, at a height of from 83 to 85 km., of "silvery clouds" (light clouds), and dust screens on the "ceiling" and in the lower layers of the stratosphere. Thus were produced those remarkable phenomena called "night dawns," which were of incomparable beauty. These were observed on the day of the fall, from the place of its occurrence as far as Spain, and from Fenno-Scandia to the Black Sea. During the night of June 30 to July 1 and the next few days, these "dawns" became gradually weaker.

The first information concerning the fall of the meteorite was gathered by the writer's expedition, which had been equipped for work in Siberia in 1921 by A. V. Loonatcharsky, People's Commissary for Public Instruction. The official scientific circles at that time did not, however, regard the accounts of this phenomenon as sufficiently trustworthy to warrant an investigation of it. In 1925-26, the writer's opinion was confirmed by new data about the fall; first, from information concerning the seismic waves, furnished by A. V. Vosnessensky, Director of the Irkutsk Observatory, and, second, from other evidence supplied by S. V. Obrootcheff, a geologist, and I. M. Soussloff, an enthnographer. Finally, in 1927, the writer had the opportunity to go to [the] Podkamennaya Tunguska to examine the place of this sensational fall. The investigation brought to light a continuous, eccentric, radial "windfall" in a huge area of radius about 30 km., which extended on some of the hills to a distance of 60 km. and even farther. Observers relate that individual trees were thrown down on the hills in the neighborhood even of Vanovara. The exceptional power of these air waves is evidenced further by the fact that in Kirensk (distant 400 km.), fences were overturned; in Kejma, people carrying grain-sacks were knocked down; and in Kansk (600 km. distant), workers were thrown from rafts into the river, while at a distance of even 700 km. to the south of Kansk, horses could not stand on their feet!

The probable figure of this "windfall," in consequence of the presence of many hills around the center of the fall, in plan reminds one of the meteorological graph called the "wind-rose." It is difficult now, of course, to estimate the dimensions of the whole area of this "windfall" without a survey. The outer fringe of the "windfall" (about 20 km. from the center) bears traces of a continuous burn from above. Moreover, the branches of the fallen trees, as well as those which still remain standing, are, as a rule, broken and destroyed. Especially characteristic is the fact that every surface of a break bears a little bit of charcoal, *i.e.* a trace of the burn. There is "no break without a burn." The central area of the "windfall" lies on permanently frozen hilly peat mosses, which alternate with swamps among the hills of the mountain watershed. This central area is surrounded by burned trees, still standing, but totally devoid of branches. The continuous "windfall" begins a little farther from the center, at a distance of one-half to one kilometer.

Pronounced meteoritic craters were not discovered in the course of the first expedition into this region. But another trip, taken in 1928 with a cinema operator, gave the writer an opportunity to explore the area of the "windfall" for a considerably greater distance, to "film" the "windfall," and to obtain, with a small

theodolite, an instrumental determination of the direction of the fallen trees and of the props [*sic:* meaning upright trees or stumps?] in the center of the "windfall," as well as to discover, in some of the depressions, the "rock flour" typical of meteoritic craters—*i.e.* fine, sharp-edged, crushed material of the surrounding rocks. Moreover, at the same time, the question was raised regarding the origin of some round excavations [depressions?] in the hilly peat mosses, about 50 m. in diameter and from 4 to 6 m. deep. A preliminary magnetic exploration of these hollows failed because of the presence of magnetic rocks (Siberian traps) in the area.

The striking picture recorded on the film and the necessity of a more detailed exploration, warranted the writer's expedition of 1929, undertaken for the purpose of making a thorough examination of this country. L. V. Schoumiliva, a geobotanist [paleobotanist?], and E. L. Krynoff, a scientific worker, took part in this trip. A small group of workers of variable number (from two to seven) proceeded for eighteen months, by surveying, excavating, constructing trenches in the frozen peat mosses, boring, *etc.*, to make a comparative study of the permanently frozen hilly peat mosses, and to obtain climatological data, in order to ascertain the extent of the permanently frozen area as well as to discover the optimum conditions for aërophotography. Accordingly, in the center of the "windfall," a hamlet was built and a small meteorological station was established. The observations secured there showed that, at the beginning of January, the region of the winter snows and the area of permanent congelation [permanently frozen ground] were everywhere coextensive. Thus was refuted the notion that the southern limit of the region of permanent congelation was located here and that underground water bubbles and funnel-shaped gaps could be formed here. Moreover, it was discovered that the end of May, when there is no more snow, but as yet no leaves on the trees, is the best time for the aërophotography of the "windfall."

In 1929, at the request of members of the expedition, S. I. Belych, an astronomer-geodesist, determined the geographical coördinates of the astro-radio points located on Mt. Farrington and Mt. Schakrama (25 km. to the south), and at the factory [of] Vanovara (about 90 km. to the southeast). In this same year, a round depression (the so-called "Funnel of Soossloff"), 200 m. to the west of the foot of Mt. Stoikovitch, was specially investigated. At the southern border of this hollow, a 40-m. trench was excavated for the drainage of the water. This cut showed great folds (up to 1½ m.) in the peat mosses and in the underlying blue clay—evidently the result of the enormous lateral pressure of the explosion gases which emanated from the meteorite. At the northern border of this asymmetric funnel, a blue, half-transparent, silica glass, containing traces of nickel, was detected in the projecting clays. In the center and at the northern and southern borders of the funnel, three pit holes were bored to a depth of 31½ m. with a 4-inch rotary shock borer of the "Empire" type. These holes showed that permanent congelation existed there at a depth of 25 m., and they terminated at a sand aquifer. In no other place were borings made.

All the valley locations in the central area of the "windfall" bear traces of a huge flood. Furthermore, the "south marsh" contains [or exhibits] a remarkable example of a concentric surge in the floating turf—characteristic evidence of the intensive subsidence of the water. Taking into account all of these facts and the configuration of the site, we can readily understand the testimony of the natives of the taiga when they relate that at the place where "it" [the meteorite] fell, water flowed out from the earth for a time. Obviously separate masses of the meteorite pierced the 25 m. of permanently frozen ground and released artesian waters,

which partially destroyed the permanently frozen hilly peat mosses.

According to available data, confirmed by the direction of the fallen trees, the center of the fall of several individual meteoritic masses is located on the northern border of the "south marsh." Here, amid the continuous marshy turf, islands of frozen hilly peat mosses remain, one of which (the eastern one) has a round funnel. This was the object of an investigation by the writer's expedition of 1929-30. Near this formation samples of material were taken, at a depth of 5 m., from the bottom of the marsh. These showed, under the microscope, minute globules of nickeliferous iron and fused aggregates of quartz grains. Finally, in 1930, native Tungus actually visited the expedition on the site of the fall of the meteorite and reported that, immediately after it fell, they found in the neighborhood of the center of the fall pieces of brilliant native iron!

It is necessary to complete the factual account of this fall by conclusions of a theoretical nature, based on considerations of matters of vital interest. We know that on June 30, 1908, behind [the] Podkamennaya Tunguska, an enormous iron meteorite fell. We may imagine that this body broke into pieces, first in the air and then in the earth's crust, which it penetrated as a number of discrete fragments, and that there (in the crust) these fragments burst into still smaller pieces under the action of the escaping incandescent gases which were produced at the time. We should expect to encounter, at a depth of hardly less than 25 m., crushed masses of this nickeliferous iron, individual pieces of which may have a weight of one or two hundred metric tons. We estimate that the whole mass of the original iron meteorite, before its encounter with the earth's atmosphere, was probably as much as several thousands of metric tons, but hardly as much as several tens of thousands.

The writer is now engaged in an attempt to obtain an aërophoto-plan of the site of the fall of this meteorite.

Moscow, Russia, 1937 May 12

The Norfork, Arkansas, Meteorite, An Iron of Witnessed Fall*

By H. H. Nininger

The subject of this paper was first brought to the attention of the Colorado Museum of Natural History through Mr. Dow Tuckness of Pueblo, Colorado, who had lately purchased it from Mr. Owen G. Kendrick of Cotter, Arkansas. Mr. Kendrick in turn had been given the specimen some years before by Mr. Isaac C. Luther of Norfork, Arkansas. The story of the meteorite as related to Mr. Kendrick by Mr. Luther is as follows[1]:

"This particular specimen fell in October, 1918, near the little town of Norfork, Arkansas. It fell in the field of Isaac C. Luther, familiarly known as 'Uncle Ike,' who gave it to me in February, 1919. 'Uncle Ike' told me at the time he gave it to me that he saw a much larger body fall, which he thought at the time fell in his field. But next morning he could find no trace of any part of it except this fragment, which he dug out of the ground. He said it was about four feet under the ground and was perfectly cold when he took it out.

"Mr. Luther has been dead several years, as you will remember by your visit here. And, unfortunately, none of his folks remembers anything definite about the matter. I have contacted his son and daughter at Norfork and all they remem-

*Read at the Fifth Annual Meeting.

[1] From a letter to the writer from Mr. Kendrick.

bered was that he dug the fragment up from where it fell and did not know the exact spot.

"I am sure that if Mr. Luther had known how to trace the meteorite, he would have found the larger body at some distance from where this piece of it fell. He said sparks were flying from it [while it was falling], like a hot iron just taken from a blacksmith's forge, and that it passed through the air with a great swishing sound, and lit up the whole place. He said that he felt sure that it fell right there in his field, and that he could get it [the] next morning. But the only place he could find where the ground had been disturbed was the place where he found this specimen."

Immediately upon examining the meteorite, it was apparent to the writer that it had been picked up while it was still in a very fresh condition. It evidenced no more traces of oxidation than would be expected on a meteorite which had been collected at the time of its fall and had then been kept about the ordinary dwelling place the length of time which Mr. Luther said it had. Since its owner placed no particular value upon it, one finds no reason for doubting the essentials of his story. An effort was made to verify the story by interviewing other residents of Norfork; but apparently there was in this community such an almost complete lack of interest in such matters that no definite corroboration could be obtained. Indeed, so little interest was taken in matters of this sort that only a very few of Mr. Luther's neighbors remembered ever having heard him tell of the meteorite's fall; they apparently entertained only a superstitious dread of such things. The writer, however, at once recalled that while he was working on the Paragould, Arkansas, fall of 1930, he had been told many times of a great meteoric display which was witnessed apparently from all points in that State and in neighboring States, especially in Oklahoma, where it was observed to travel in an eastward direction. The year given was 1918. It is possible that this was the same meteor as that reported by Mr. Luther; but at this late date it is impossible to say definitely whether there is a connection between the two phenomena. Possibly such a connection would be strengthened by a search into the records of the daily press. On the basis, however, of the condition of the Norfork meteorite fragment and its finder's story, we feel justified in recording it as a witnessed fall of uncertain date. All of the details of surface markings characteristic of metallic meteorites of witnessed fall are perfectly preserved in this specimen, with the exception of a slight mutilation from hammer blows and the small amount of rusting which it had undergone.

As it arrived at the Colorado Museum of Natural History, the specimen weighed 1050 grams. Except where freshly broken, or where bright nickel-iron was exposed, the surface was enveloped in the usual thin, bluish-black crust, characteristic of freshly fallen metallic meteorites. The meteorite was in the form of a three-sided, irregular, much pitted mass. One side bore beautiful flight markings in the form of abundant thread-lines, like brush marks, spreading over its undulating surface. Adjoining this face was a more heavily pitted side of the iron, bearing a conspicuous fusion crust but lacking the "brush marks"; where these two faces joined, there was a conspicuous lip which appeared to have been produced by pressure from the "brush-marked" side, together with an accumulation of spilled-over, molten iron, well shown in Fig. 1. At many points the bright nickel-iron was prominently exposed. All of the markings indicated that this second face mentioned was rearward during the time when the thread-lines were formed. This fact is, however, extraordinary, in view of the pitting of the face, as the rear sides of meteorites are marked with pits which are usually broad-

er and not so deep as those of the forward sides. Perhaps the present instance would appear more typical if we had more of the original meteorite for inspection.

FIGURE 1

The Norfork, Arkansas, meteorite, showing the accumulation of spilled-over, molten iron where the two faces join.

FIGURE 2

A fresh break in the Norfork meteorite, showing the exposed faces of the octahedral plates.

FIGURE 3

Etched section of Norfork meteorite, showing typical octahedral crystallization, three small nodules of troilite, and a marked alteration zone beneath the fusion crust on the right.

Evidently the fragment had been torn from a much larger mass just before, or at the time of landing, for the third face obviously represents a fresh break (see Fig. 2). Here the entire surface is characterized by the exposed faces of the octahedral plates, or their torn, jagged edges. It appears that our specimen represents a corner of a large mass which was detached just as the main body penetrated the soil. Several iron meteorites are known which bore, at the time of their finding, fractures of this type, except that the parts had not been completely detached. Evidently, such a fracture might easily result in the detachment of a fragment on its impact with the soil. Scientific men can never cease to regret that Mr. Luther did not mark and report the location where this piece was found and allow the place to be properly investigated. Doubtless a meteorite lies buried there which would rival the finest specimens ever seen by human eyes! All of the writer's efforts to locate the spot were fruitless, largely on account of the total lack of interest on the part of the local citizenry.

Three thin slices were cut from the specimen, parallel to the small flattish face shown in the lower part of Fig. 1. When polished and etched, these showed the usual Widmanstätten pattern of a medium octahedrite, with some conspicuous fractures and a very evident alteration zone bordering the edges. This alteration zone varied from 1 mm. to 7 mm. in thickness. Small inclusions of troilite were noted, but they were very scarce. No schreibersite was recognizable on the surfaces examined.

Metallic meteorites of witnessed fall are very rare in collections. Only six falls have been recorded for the whole continent of North America. One of these (that of Mariaville, Nebraska) has been questioned by Dr. O. C. Farrington[3] and a second one (that of Norfolk, Virginia) is regarded by the writer as questionable. The six recorded "witnessed falls" are as follows:

AUTHENTIC WITNESSED FALLS OF METALLIC METEORITES IN NORTH AMERICA

(1) *Cabin Creek, Johnson Co., Arkansas;* fell 1886 March 27, 3:00 P.M.; wt. 107 lbs. (49 kgs.); one mass.
(2) *Charlotte, Dickson Co., Tennessee;* fell 1835 July 31 or August 1, about 2:00 or 3:00 P.M.; wt. 9.5 lbs. (4.3 kgs.); one mass.
(3) *Mazapil, Zacatecas, Mexico;* fell 1885 November 27, 9:00 P.M.; wt. 8.8 lbs. (4 kgs.); one mass.
(4) *Pitts, Wilcox Co., Georgia;* fell 1921 April 20, 9:00 A.M.; wt. 8.2 lbs. (3.7 kgs.); four masses.

QUESTIONABLE RECORDS OF METALLIC-METEORITE FALLS IN NORTH AMERICA

(5) *Mariaville, Rock Co., Nebraska:* This small iron meteorite was described by E. H. Barbour, *Rep. Neb. Geol. Survey,* **1**, 184, 1903. He stated that the finder said it had been seen to fall between 12:00 and 1:00 o'clock on the night of October 16, 1898.

The present writer interviewed the finder of this meteorite in 1931, who stated that from a neighboring farm he had witnessed a large meteor or fireball come to earth in the direction of his father's farmhouse. Four years later, while he was excavating for the building of a cave in his father's yard, he encountered this small meteorite. This circumstance, of course, constitutes no evidence of any connection between the meteorite found and the meteor seen four years earlier. The fact that the meteor appeared to come to earth is evidence of its great distance from the observer. Meteorites of its size have not been known to continue luminous below

[3] *Mem. Nat. Acad. Sci.,* **13**, 292-3, 1915.

an elevation of several miles above sea level. This fact would indicate that the meteor in question reached the earth, if at all, a hundred miles or more away from the observer. No sound was reported, and the meteorite found later indicated great age by its weathered condition and heavy oxide scale. Dr. George P. Merrill once wrote that probably no meteorite was ever found for which a fireball could not be recalled as having been seen in the proper direction to account for it; but he pointed out that such a recollection was of itself no evidence of a connection between the fireball and the meteorite. The Mariaville meteorite should, therefore, be recorded as simply a find.

(6) *Norfolk, Montgomery Co., Virginia:* This meteorite was briefly mentioned by Lewis W. MacNaughton and Chester A. Reeds in *Am. Mus. Novitates,* No. 207, 1926, as a witnessed fall, but no evidence was cited to prove that it was such. The specimen has been examined by the writer, and surely its badly oxidized condition indicates as great an age as does that of the average metallic find.

The writer has collected many meteorites, and seldom has the finder failed to report that he had seen his specimen fall, in spite of the fact that most of these finds bear in themselves sufficient evidence of a considerable period of weathering. Meteorites have been falling upon the earth doubtless throughout all geologic time. The finding of those which have lain on the earth for some years is much more likely to happen than is the finding of a freshly fallen specimen. Before recording a meteorite as a witnessed fall, conclusive evidence should be obtained from persons who have actually seen its impact with the soil, or through such evidence as:

(*a*) *Freshly disturbed* soil, vegetation, or other surface objects;

(*b*) A *careful survey* of reported aërial phenomena, which should indicate the *site* of the find;

(*c*) In every case, *evidence in the specimen itself,* which should be indicative of its *recent arrival* on the earth.

Meteorites arrive from a region where oxygen is scarce or absent. Consequently, the condition of their mineral constituents is noticeably different from that which characterizes terrestrial metals and rocks. In addition to this fact, meteorites undergo, during their plunge through our atmosphere, a treatment not accorded to any terrestrial object. Therefore, a careful examination of a specimen by one familiar with these bodies will enable him to determine within rather narrow limits the amount of weathering to which it has been exposed. By far the most important testimony as to the approximate terrestrial age of a fallen meteorite must come always from a study of the meteorite itself.

The Norfork, Baxter Co., Arkansas, meteorite is, therefore, regarded by the writer as the fifth metallic meteorite of witnessed fall in North America. Though the date of its fall is somewhat uncertain, the freshness of the specimen cannot be questioned, and the recorded month and year may be regarded as reasonably sure. It is regrettable that not more of the details regarding this fall were recorded at the time of its occurrence, and still more serious is the fact that an adequate search was not made for the remainder of the mass, which the writer believes lies buried in the hole from which our specimen was recovered. Similar detached chunks were found in excavations for the great Estherville, Iowa, fall and in several other similar cases.

The name *Norfork* should not be confused with *Norfolk,* which, as has been previously noted, is the name of a metallic meteorite from Virginia, the main mass

of which is now preserved in the American Museum of Natural History, New York City, and which, as has been stated, was probably not a witnessed fall. The subject of this paper was found within a half a mile or less of the village of Norfork, Arkansas, which is situated in the south central part of Baxter County, at the junction of the North Fork and the White River. The specimen was recovered from a place whose coördinates are approximately long. W. 92° 17′, lat. N. 36° 12′.

Notice concerning Membership Dues and Subscriptions

The attention of members is called to the fact that, in pursuance of Art. III, Sec. 1 of the *By-Laws of the Society*, as adopted at the Fifth Annual Meeting in June, 1937, and effective January 1, 1938, "The annual dues of every member shall be two dollars ($2.00) [instead of one, as heretofore], payable to the Treasurer on the date of election and on January 1 of every year thereafter." Accordingly, the combined membership fee and subscription price to POPULAR ASTRONOMY will be henceforth $5.00 per year to members in the United States and $5.50 to those in other countries. All remittances for the year 1938, including both dues and subscriptions, should be made payable and forwarded, on or before January 1, 1938, to the *Treasurer of the Society, Mr. L. F. Brady, Mesa Ranch School, Mesa, Arizona.*

Comet Notes

By G. VAN BIESBROECK

This month the only known comet in reach of ordinary telescopes is PERIODIC COMET 1937 *h* (ENCKE). It passed nearest to the earth on November 15 as shown by the ephemeris which was given on p. 496. When last observed here (Nov. 10) before the full moon it had a tiny stellar nucleus not brighter than a star of magnitude 13, followed by a very eccentric fanshaped coma extending to a distance of 6′ from the nucleus. This coma was in the direction of the sun while on the opposite side, where normally the tail would appear, there was no material visible. The total brightness at that time was estimated extrafocally as 11^M. The ephemeris published by the Pulkova Observatory is continued here for December. The much impaired visibility will be limited to the first evening hour until December 11 when the comet is in conjunction with the sun and separated from it by only 14 degrees. After that date there is a slight chance to see the comet just before sunrise.

EPHEMERIS FOR COMET 1937 *h* (ENCKE)

1937		α h m	δ ° ′	Distance from Earth	Distance from Sun	Mag.
Dec.	2	17 56.7	+ 2 16	0.355	0.710	6.9
	3	51.1	+ 0 54			
	4	45.7	− 0 27			
	5	40.4	1 45			
	6	35.4	3 1	0.398	0.636	6.6
	7	30.6	4 14			
	8	25.9	5 26			
	9	21.5	6 35			
	10	17.3	7 42	0.452	0.562	6.4
	11	13.3	8 47			
	12	9.5	9 51			
	13	6.0	10 53			
	14	2.8	11 53	0.520	0.489	6.1
	15	16 59.8	12 51			
	16	57.1	13 48			

1937	α h m	δ ° ′	——Distance from—— Earth	Sun	Mag.
Dec. 17	16 54.8	—14 44			
18	52.8	15 38	0.605	0.421	5.7
19	51.3	16 30			
20	50.1	17 22			
21	49.5	18 12			
22	49.3	19 0	0.710	0.367	5.5
23	49.6	19 47			
24	50.5	20 33			
25	51.9	21 17			
26	53.9	22 0	0.834	0.336	5.5
27	56.4	22 40			
28	16 59.5	23 18			
29	17 3.1	23 54			
30	7.1	24 28	0.968	0.339	5.8
31	17 11.4	—24 59			

The brightness is greatest in the second half of the month, but nearly 3 magnitudes fainter than predicted here. Perihelion occurs on December 28 after which time the comet is best situated for southern observers.

P. S. (November 22). Comet Encke has brightened up considerably: total intensity, Nov. 21, 8^M; Nov. 22, $7^M.5$, corresponding closely to the ephemeris.

With large telescopes several faint comets remain under observation: COMET 1937 *b* (WHIPPLE), COMET 1937 *g* (HUBBLE), and COMET 1935 *d* (VAN BIESBROECK). But they are all very faint and on the decline.

G. Neujmin gives in Circular 688 of the International Astronomical Union a search ephemeris for his second period comet which was last observed in 1927. On November 11 the writer could not detect it in the expected position although stars as faint as 15^M were visible on the plates. The computer, however, does not expect the object to be brighter than 15^M to 16^M and it is none too well placed in the morning sky. The computed perihelion time is November 21 and no increase in brightness is expected.

The search for PERIODIC COMET 1927 VI (GALE) should be started in December. The following ephemeris by M. Sumner indicates the region but there is considerable uncertainty as to the exact location.

1937	α h m s	δ ° ′	——Distance from—— Earth	Sun
Dec. 5	13 51 57	—2 58	2.64	2.08
13	14 9 35	4 40	2.50	2.01
21	27 45	6 23	2.36	1.93
29	47 12	8 6	2.23	1.86
37	15 7 57	—9 52	2.10	1.79

This comet reached magnitude 8 in 1927 so that there is a fair chance of recovery next spring. Perihelion is predicted for 1938 April 19. The object must of course be quite faint yet at this time.

Williams Bay, Wisconsin, November 20, 1937.

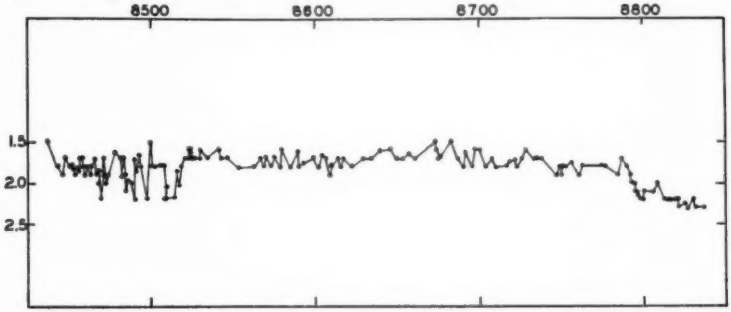
VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Gamma Cassiopeiae: This interesting star, which a year ago caused considerable excitement among variable star observers, has now decreased in brightness. Visual estimates indicate a diminution in light from magnitude 1.6 in May, 1937, to 2.3 at the end of October. Dr. C. M. Huffer reports a decrease of 0.7 of a magnitude since the maximum of May 7; at magnitude 2.46 on October 30. His measures were made with a photoelectric cell photometer and he states that the decrease has been at the rate of 0.17 of a magnitude per month.

A plot of the visual observations contributed by the A.A.V.S.O. members since October, 1936, to the end of October, 1937, is shown and indicates a more or less steady rise in brightness to May, 1937, and then a gradual drop, becoming more rapid during the month of October. The earlier estimates appear to be more scattered than the later results, but no correction for personal equation has been applied to any of the visual observations. The plotted points are daily means.



LIGHT VARIATIONS OF GAMMA CASSIOPEIAE, OCTOBER, 1936, TO NOVEMBER, 1937.

This star should be closely followed during the coming months, if possible, by photometric methods, in order to note any peculiarities which may occur.

Novae in Sagittarius: To the already large number of novae discovered in the constellation of Sagittarius there have recently been added two others, one found by Miss Cora Burwell at Mt. Wilson Observatory and the other by Mrs. Mayall at Harvard Observatory.

Miss Burwell's nova rose very suddenly from below magnitude 12.7 on March 31, 1936, to 7.5 on April 2. From then it increased still further in brilliance until magnitude 6.5 was attained on April 24. On May 25 the nova began to fade and the descent to minimum was both rapid and uniform. Early in September it had decreased to 12.5. There appears to be a K-type star, possibly of the 12th magnitude, involved in the estimates of the brightness of the nova, with the probability that the nova actually rose from, and dropped to, a much fainter magnitude than 12.5. This nova was above normal minimum magnitude, brighter than the

12th, for about three months only, with more than two months of that time spent at actual maximum, brighter than magnitude 7.5. The decrease to minimum was comparable to that of Nova Herculis in 1935, when it made its rapid descent to minimum, just prior to its second outburst.

The latest nova in Sagittarius was found by Mrs. Mayall on November 10, 1937, on a special spectrum patrol plate taken on May 29, 1936. The spectrum was then of the advanced nova type, decidedly peculiar for one taken less than a month after maximum. This nova was fainter than magnitude 16.5 on April 30, 1936, and at magnitude 10.8 on May 13. It is quite possible that the nova attained a still brighter maximum than that reached on May 13, and that it was actually fading when photographed on that date. Here again we have an outburst in the light of a star lasting only about three months, although the time spent at maximum was probably only a few days. This is quite in contrast to the two months during which Miss Burwell's nova was near maximum. The form of the light curve of Mrs. Mayall's nova closely resembles that of RS Ophiuchi at its 1933 maximum.

The constellation of Sagittarius seems to be the favorite hunting-ground for novae in our own galaxy. Of the slightly more than one hundred novae already discovered in our stellar system, more than a score made their appearance in Sagittarius, most of them grouped around galactic longitude 330°, latitude —7°. Of the twenty-one definitely considered as novae in this constellation, 16 were discovered from Harvard plates, 4 from photographs taken at other observatories, and one was discovered visually by Okabayashi in October, 1936. Thus three novae burst forth in the constellation of Sagittarius during a period of six months in 1936. A table containing known facts about novae in Sagittarius is appended. The year of maximum is given in the first column, followed by the designation number. The magnitude at maximum and minimum are next given, together with the name of the discoverer. Three other stars, suspected as being of the nova type by Innes, are given at the end of the table.

NOVAE DISCOVERED IN SAGITTARIUS

Year Maximum	Designation Number	Magnitude Max.	Min.	Discoverer
1893	1754*35*	12.5	[16.5	Swope
1897	1822*27*	13.0	[15.5	Woods
1898	1856*13*	4.8	15	Fleming
1899	1813*25*	8.5	14.5	Cannon
1900	1822*21*	11.6	16.5	Woods
1901	1800*27*	10.3	[15	Cannon
1905	1802*32*	7.1	[17	Woods
1910	1753*27*	8.1	15.4	Fleming
1914	1759*31*	8	[17	Woods
1917	1820*27*	9	[17	Innes
1919	1825*29*	7	14	Woods
1924	1816*25*	11.4	14.0	Woods
1924	1753*34*	8.4	[13	Gill
1926	1811*23*	8.6	[16	Cannon
1926	1755*26*	10.6	[16.0	Woods
1927	1905*30*	8.8	16	Becker
1930	1815*25*	8.7	16.0	Hoffleit
1931	1841*25*	12.9	[15.3	Ferwerda
1936	1749*27*	6.5	[12.5	Burwell
1936	1813*26*	10.8	[16.5	Mayall
1936	1802*34*	4.5	[14.0	Okabayashi
1912	1828*29*	11	[17	Innes
1914	1828*26*	14.2	[14.7	Innes
1914	1835*28*	15.8	[17	Innes

SS Cygni Type Variables: The past six months have given us little data on the SS Cygni type stars except for the prototype star, SS Cygni. During this interval SS Cygni has passed through three well-observed maxima, numbers 293, 294, and 295. The first and last were identical in shape, of the C6 form (slow rise and of long duration) while the intermediate maximum, 294, was of the A3 form (rapid rise and relatively short duration). Number 293 occurred in May, 294 in July, and 295 in September, with relatively long intervals between, 52 and 68 days, respectively.

U Geminorum escaped detection at maximum except for a lone observation on October 29, when it was estimated to be at magnitude 9.9.

SS Aurigae has also been rather sparsely observed, especially at maximum. There appear to have been indications of maxima during July and October. UV Persei was at maximum, magnitude 12.5, late in September. AY Lyrae was bright late in June, in September, and again in October. RU Pegasi passed to a sharply defined maximum, magnitude 11.0, in the middle of October. There appears to be a close companion to RU Pegasi which evidently confuses observers enough to cause apparent irregularities in the light curve at minimum.

R Coronae Borealis Type Variables: All of the best known stars of the R Coronae Borealis type are now at maximum; SU Tauri, slightly above the tenth magnitude during the past year or more; S Apodis, approximately of the tenth magnitude since September, 1935; R Coronae Borealis itself has been at sixth magnitude since early in 1936; and RY Sagittarii, at the seventh magnitude since August of this year. The recent minimum of this last star was of much shorter duration than usual. There were two somewhat deep minima with a secondary maximum at magnitude 7.8, before the star finally ascended to its full brightness.

Notes on Two Eclipsing Variables: Dr. S. Gaposchkin finds from a discussion of the observations of UX Ursae Majoris, the eclipsing variable with the shortest known period ($0^d.197$), that the absolute magnitudes of the two components are 5.2 and 8.0, respectively. With the brighter component having a spectrum of type A2, this star takes its place in the Russell diagram between the normal sequence and the white dwarfs.

Dr. S. Gaposchkin has also obtained a photographic light curve of the star WZ Ophiuchi from the Harvard patrol plates. This agrees remarkably well with the visual curve derived from Leiner's observations. WZ Ophiuchi is one of the few eclipsing variables for which radial velocities of both components have been observed at Mount Wilson. The system is remarkable in that the duration of the eclipse is only five one-hundredths of the entire period of the star—a value second to that found for Zeta Aurigae, which is three hundredths. Both components have the same spectral type, G0. In the case of WZ Ophiuchi we have an instance where the two components are approximately of an equal size, equal brightness, equal mass, and of equal density, comparable to our sun.

Observers and Observations During October, 1937: The following list contains the names of the observers, together with the number of stars observed by each, and the number of estimates made on variable stars contributed during the month of October, 1937. A total of 5724 observations by 58 observers is a splendid record for a single month.

Observer	Vars.	Observations	Observer	Vars.	Observations
Ahnert	34	317	Baldwin	117	286
Ancarani	18	40	Ballhaussen	6	6
Ashbrook	2	62	Benini	3	19

Observer	Vars.	Observations	Observer	Vars.	Observations
Bouton	39	40	de Kock	42	153
Blunck	60	69	Kozawa	18	56
Brocchi	4	10	Loreta	112	375
Buckstaff	17	68	Millard	41	74
Callum	37	75	Monnig	7	7
Cameron	10	12	Murphy	26	60
Carpenter	194	206	McLeod	22	66
Cousins	18	35	McNabb	2	5
Dafter	8	12	Peck	24	60
Diedrich	1	1	Peltier	183	210
Ellis	46	78	Purdy	6	7
Ensor	79	134	Rosebrugh	16	65
Fairbanks	14	29	de Roy	19	157
Fernald	6	26	Russell	20	34
Franklin	40	69	Seely	8	38
Gregory	22	22	Schultz	12	12
Hartmann	154	304	Sill	122	176
Herbig	91	200	Smith, F. P.	49	86
Hiett	20	64	Smith, F. W.	4	12
Hildom, A.	24	42	Smith, L.	11	11
Holmes	3	4	Topham	5	8
Holt	38	64	Treadwell	19	114
Houghton	71	178	Webb	41	47
Houston	135	800	Woods	40	88
Jones, E. H.	93	352	Yamasaki	23	30
Kirkpatrick	26	122			
Knott	21	27	Total		5724

November 17, 1937.

Notes from Amateurs

Amateur Astronomical Society of New Haven

By invitation of Professor Slocum, head of the Van Vleck Observatory, the October 11 meeting of the New Haven Amateur Astronomical Society was held in the lecture room of the Observatory in Middletown, Connecticut, with thirty-two attending.

The early part of the evening while we were traveling to Middletown was clear. The party assembled in the library, and divided, to visit the observatory room. The huge telescope was set, the massive dome moved to position, and the group witnessed a perfect eclipse of the entire heavens by clouds, nothing at all could be observed. Professor Slocum very tactfully met the unfavorable situation by explaining the working of and the use of the many appliances used in the work with the 20-inch refractor. The tube is twenty-eight feet long, and weighs one and one-half tons. The chief work done is the measuring of star distances, and Professor Slocum explained in detail, augmented with a number of blackboard sketches, the methods employed and difficulties encountered in measuring a star's parallax. The 184,000,000-mile diameter of the earth's orbit is used as a base line and even then producing only an angle of a small fraction of a second of arc. He informed the group that it required twenty to thirty plates and about two years to determine a parallax.

He explained the method and showed the group the small and simple instrument used to cut down the light registered on a photographic plate when determin-

ing the parallax of a bright star, stating the light could be cut down 10,000 times.

He also fully explained the workings of the chronograph which is used for exact timing of transits, occultations, eclipses, etc. This timing instrument which is in a central room is operated by remote control from any room or place when exact time is required. By means of a push-botton held in the hand of the observer, the time is recorded on a graphic chart by a pencil tracing a straight line with every second plainly indicated by a "V"-shaped mark. When the button is pressed a distinctive mark is made on the chart and, when the observation is completed, the chart is removed from the cylinder and the exact time within a fraction of a second is readily checked and that chart then filed for reference.

The many and varied questions asked Professor Slocum were very quickly and willingly answered and the visit will long be remembered as one of the high-spots of our society's meetings.

F. R. BURNHAM, *Secretary.*

Cleveland Astronomical Society

Our meeting for November was well attended as usual. To find a seat it is always necessary to be on hand early. Dr. H. F. Donner spoke on "Astronomy in South Africa." Dr. Donner has spent six years in Bloemfontein, South Africa, at the southern station of the University of Michigan Observatory and gave us an insight into life as well as astronomy in South Africa. Fine moving pictures served to supplement the lecture. Many of them were remarkable scenes of wild life at close range of the larger animals which a southern astronomer might meet unexpectedly. The success of our society is due largely to our President, Dr. J. J. Nassau, who always seems able to provide the very best speakers for our meetings. A distinguished guest was Professor J. S. Plaskett of the Dominion Astrophysical Observatory who made a few remarks.

DON H. JOHNSTON.

14 Lincoln Drive, Cleveland, Ohio.

Aurora Borealis and Sunspots

On the night of October 3 there was a fine display of Northern Lights visible in Ottawa. They showed an arc with many streamers reaching up to the zenith. Later the arc disappeared but the streamers persisted almost like flames flickering up to the zenith but not reaching beyond it.

On the evening of October 4, there was a fairly thick haze which toned the sun's light down to a rich copper color and made it easy to observe the whole disc without injury to the eyesight. Almost in the center of the disc was a tremendous spot nearly as large as the huge spot of August of this year. This spot was easily visible to the naked eye.

Again on the night of October 6 we had one of the most brilliant displays of Northern Lights that I have ever seen. These were of a different type from those of the night of the 3rd, being in the shape of large patches of light which brightened and then disappeared. The whole sky seemed to be pulsating and trembling with a soft yellowish light even some of these patches flickering to the extreme parts of the southern sky.

The radio was badly affected both nights and I have seen in the papers that telegraph and telephone lines were also.

G. MCFARLANE.

490 Cooper Street, Ottawa, Canada, October 20, 1937.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editors may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Astrological Fallacies*

To establish a conjectural basis for astrology we should need accurate birth records for at least several million persons of different nations and races; accurate astronomical data for each one; careful, detailed personal history, correlated, studied, and, for the purpose of making predictions, reduced to uniformities, if any.

No such statistics exist. In the dim recesses of antiquity we find instead the roots of astrology entwined with manners, customs, medicine, politics, agriculture, and religion, infused with the wild fancies of the myth-maker. Saturn, troublesome fellow among the gods, becomes a malignant planet in the heavens. His gloomy, leaden character is embalmed in our adjective "saturnine" and in the old chemical term "saccharum saturni" for sugar of lead.

The intelligent augurs of ancient Rome, 'tis said, could not look at each other without laughing. According to Cicero, not one of the futures foretold for Crassus, Pompey, and Caesar was verified by their later lives, while Pliny, the Elder, declared the horoscopes of twins practically identical, but their careers often were very different; every hour in every part of the world were born lords and slaves, kings and beggars.

Extend that. There are now over two billion living. Nobody knows how many billions have come and gone,—red, brown, black, white, and yellow, with variations; physically and mentally, from pigmies to giants. Some come into the world, like Richard III, "scarce half made up," and others even worse. Why may not such a defective be born at the same time, in the same immediate neighborhood and under the same starry influences, as a genius? On February 12, 1809, couldn't a dunce have been born in a nearby Kentucky cabin under the same sign as Abraham Lincoln, and an idiot in a nearby Shrewsbury dwelling under the same sign as Charles Darwin? In our great hospitals babies of different kinds, colors, and nationalities are born at so nearly the same time that an astrologer would have to give the same horoscope for them. Yet how different their lives and destinies!

In 1348 a terrible plague swept through Europe. Man, woman, and child, rich and poor, good and bad, went under indiscriminately. Add other visitations like that of 1665-6, vividly described by Daniel Defoe; and matched by McMaster's story of yellow fever epidemics in Philadelphia between 1790 and 1800. Epidemics like these would make the morbific planets work overtime so much that even an astrologer would find it difficult to make the signs square with the facts. For the hundreds of thousands who died he would have to find horoscopes all foretelling the same fate. The stars no longer predict yellow fever for Philadelphia.

Judging astrology, the scientist weighs the human propensity to exaggerate successes and minimize failures. He will throw out of court indefinite predictions like, "This month a well-known statesman will die." In such a case the astrologer

*Condensed from address delivered March 12, 1937, at the meeting of the Rittenhouse Astronomical Society in the Franklin Institute, Philadelphia.

plays both ends against the middle. But even a skeptic may admire Cardan's specific prediction for King Edward the Sixth. Edward was only fifteen; his guardians were eager to know how long he would live. Cardan, the scientist who embezzled Tartaglia's solution of the cubic, Cardan, the most famous astrologer of his day, cast and read Edward's horoscope with unusual care. In October, 1552, he predicted that the King would surely live past middle age; after the age of 55 various diseases would fall to his lot. Edward died the following July in his 16th year. Cardan included the case among a dozen well-authenticated failures, but asserted that he should have had a horoscope for every one intimately associated with Edward.

George Wharton, astrologer to King Charles I, declared "His Majesty shall be exceeding successful in besieging towns, castles or forts, and in pursuing the enemy. Believe it, London, thy miseries approach, unless thou seasonably crave pardon and submit to thy Prince's mercy." But London didn't; instead Charles lost not only his army and his crown, but also his head.

A few years ago three of us sent requests to the best-advertised astrologer. We added another for a young man who had died fifteen years before. He had been born seriously defective. In a few days there arrived a horoscope for each of us, that for the substandard boy being especially good. Not long after, the astrologer died. Seeking business, her successor sent out followup letters. The only one received here was addressed to the defective young man, who had died fifteen years before!

RICHARD P. LOCHNER.

General Notes

Dr. Harlow Shapley Visits Louisville, Kentucky

On Monday, November 8, Louisville was honored by a visit from Dr. Harlow Shapley, Director of the Harvard Observatory. He was the guest of the Harvard Club of Kentucky and the Louisville Astronomical Society. A committee composed of members of both groups and other prominent citizens met Dr. Shapley upon his arrival.

The Harvard Club entertained the famous visitor at a dinner at the Pendennis Club after which Dr. Shapley lectured at the Playhouse on Belknap Campus, University of Louisville.

The lecture was illustrated with beautiful photographic slides. Many of these were taken at the Harvard Observatories in South Africa, showing vast galactic systems and other astronomical bodies. Also pictures of the very interesting country in which these observatories are located.

Following the lecture the Louisville Astronomical Society held an informal reception at the Playhouse in honor of Dr. Shapley. Among the 475 who attended the lecture and reception were guests from Indiana University, University of Kentucky, and several nearby towns.

LOUISVILLE ASTRONOMICAL SOCIETY, MARY EBERHARD, *Secretary.*

German Astronomers to visit the United States.—Definite plans have been made for conducting German scientists on a tour to the United States next summer. The party will sail from Hamburg on the "Deutschland" on June 30, 1938. Fourteen days will be spent in visiting places of interest here. Included in the

itinerary are: Harvard Observatory, U. S. Naval Observatory, Yerkes Observatory, Bausch and Lomb Optical Works, Eastman Kodak Co. Plant, Bureau of Standards, American Museum of Natural History, Franklin Institute, and the large cities directly or indirectly connected with such a tour.

The Steward Observatory Fellowship

The Steward Observatory fellowship at the University of Arizona is expected to be available for the academic year 1938-39. The fellowship carries a stipend of approximately $450 as well as exemption from tuition fees, and the recipient may be called upon for about one-third of his time for assistance with the research programs of the observatory. This work will probably consist largely of helping with photoelectric and photographic observations. No assistance with teaching will be involved.

The fellow will be expected to use the 36-inch reflecting telescope in a program of his own in the fields of photographic or photoelectric photometry, and he may submit the work as a thesis for the master's degree at the University of Arizona.

During the past two years the fellowship has been held by candidates for the doctorate at other institutions who have obtained the observational material for their theses with the reflector. The Harvard and Lick Observatories have thus far participated in this procedure, and it has proved so successful that its continuance is desired. Therefore preference will be given to those who apply for the fellowship under this plan. Application should be made before March 1, 1938, to Professor A. E. Douglass, Director of the Steward Observatory, Tucson, Arizona.

Northern Lights Phenomenon?

At 6:00 P.M. on October 20, 1937, in a clear sky there was a very noticeable band of creamy white light of uniform width (about three degrees) extending from the eastern to the western horizon along the ecliptic. The full moon was directly in the path about ten degrees above the eastern horizon. Wind was blowing from the southwest. It did not resemble either smoke or cloud. It lasted not less than twelve minutes and the sky clouded over soon after.

Berea College, Berea, Kentucky. RUBY BURCHAM, PAUL DERTHICK.

Partial Eclipse of the Moon, November 18, 1937

The partial eclipse of the moon, early this morning, was followed from Tredyffrin Observatory. The times published were 2:37, 3:17, and 4:00. The edge of the shadow cone is uncertain because, like all shadows, it lacks sharpness of outline. Toward the maximum the outer fringe of shadow touched the crater Tycho, but did not cover it in the way it nearly obliterated the lunar landscape between it and the southern limb. Estimated the depth of the shadow as about twice the darkness of the principal maria. The observing conditions were nearly ideal: magnificently clear sky, excellent definition, quiet air. Used the Herschel solar eyepiece without dark glass, which proved ideal for the purpose. Magnification about 40—negative. Published information stated the total obscuration as one-seventh of the area of the disk, but it seemed to me to be more nearly one-eighth or less. Although the time of egress from the shadow cone was given as 4:00 o'clock, the limb was still somewhat darker at that point for five or six minutes later, as if yet in the outermost edge of shadow.

Under such excellent definition, even with low power, the limb of the moon is very perceptibly irregular—not a sharp circular contour as in the case of the sun during fine definition.

While to the naked eye, as the shadow seems to bite into the disk of the moon, the darkened area is destitute of detail, including the arc of the limb, and somewhat less so with the Dollond astronomical binoculars, in the 4-inch instrument the limb was always plainly perceptible, and along the fringe of shadow arc there was considerable detail visible. When the light of the moon, at full, is reduced by means of the Herschel helioscope, the details of the surface stand out rather more sharply than without that help, this being particularly the case with the rill system extending from Tycho.

H. B. RUMRILL.

Tredyffrin Observatory, Berwyn, Pennsylvania, November 18, 1927.

Book Reviews

Photography of the Planets, by H. J. Gramatzki. (Ferd Dümmlers Verlag, Berlin.)

The above is the translation of the title of a pamphlet of seventy-two pages by an author who is well known for his writings on astronomical subjects. This work is written in German. In the introduction the writer calls attention to the extensive work done in America along the line of photographing the planets. His work is designed to stimulate the workers in Europe to like activity. The theoretical aspects of the problem are thoroughly considered with mathematical formulas and with the necessary diagrams. One chapter is devoted to the practical aspects also. This book doubtless will serve as a useful handbook for those who can readily extract the meaning from the German text. C.H.G.

The Romance of the Calendar, by P. W. Wilson. (W. W. Norton, New York, 1937, $3.00.)

The title of this work is happily chosen. It is more than a history; although it is replete with historical facts and inferences, it also "surveys the development and significance of the calendar as a whole." Not only does it bring to the reader a clear picture of the experiments which resulted in the many calendars through the ages, but it discusses in detail plans for a more scientific calendar to be used in the future.

The science of chronology, according to the author, "is a science that is illuminated by sun, moon, and stars; and the alphabet of chronology is the calendar." The measurement of time may be regarded as man's first cultural thought—the calendar started when man looked beyond himself, to the future and to the past. There must have been as many calendars as there were civilized communities, and the bases for reckoning time were variable, including botanical phenomena, hydrographical phenomena, climatic conditions, etc. To this day there is no universal calendar; the author says "for certain purposes great communities—Chinese, Moslems, Hindus, Jews, and the Eastern churches among them—continue their own systems of measuring time."

As would be expected, the history of the calendar has been the history of a succession of adoptions and rejections of systems of measuring time and then of formulation of new systems. Man demanded a method of time-measurement which

would be convenient as well as accordant with the apparent motion of sun and moon. Man early discovered the moon's synodic period of 29½ days and determined the length of the solar year, 365¼ days. But it was many centuries before he concluded that the two periods were incommensurable, many centuries before he gave up attempting to equate his calendar of lunar months to cycles of solar years.

The early history of the calendar is the history of rival claims of the moon and sun for authority over the calendar. It is the history of many methods of intercalation of days and months into the solar year in an effort to arrive at an accurate correspondence between multiples of solar year and multiples of the lunar month. It is the story of intercalation according to the whim of the pontiffs, the story of Julius Caesar's reform of the calendar, namely his adoption of the earlier calendar of Ptolemy Euergetes, now known as the Julian calendar. It is the story of the Gregorian modifications of 1582 (our present calendar), the story of religious attitudes toward these calendars, and the influence which resulted when the various sects championed one calendar or another. It is truly a romance.

The last section of the book is devoted to a discussion of proposed revisions of the calendar, their merits and difficulties. The treatment is complete and well written, and should be studied by all those interested in calendar reform and by others as well. The proposed World Calendar consisting of four quarters of 91 days each with leap day inserted between June and July, each quarter beginning with Sunday, and the months each having 26 working days, is being much discussed at present. New Year's Day, a holiday, begins the year and is not a part of any of the quarters.

The author amply supports his statement that the "world calendar does not merely regularize the year. It contributes greatly to the use of the year for the purposes of worship, enjoyment, and recreation."

The book is the more valuable for the complete chronology and index which it contains. M. R.

Unveiling the Universe, by Norton Wagner. (Research Publishers, Scranton, Pa. $1.00.)

A book recently issued under the above title presents, as is stated in the early pages, "a concise summary of historical, descriptive, and observational astronomy, so illustrated and described that amateurs, school students, and lay readers may readily acquire a visual, comprehensive knowledge of earth's companion planets and the other celestial bodies that dwell in our surrounding universe." It contains a multitude of interesting illustrations accompanied by very readable descriptions. It begins with the earliest known astronomical lore and includes a photograph of the model of the 200-inch reflector now under construction. It might have been better to have expanded the book somewhat, used larger type and better printing paper, but this would necessarily have increased the cost of the book. Probably in no other volume of this price can so much information be obtained.

C.H.G.

Lange's Handbook of Chemistry, Second Edition. (Handbook Publishers' Inc., 1937.)

This handbook supplies the usual data on approximately 5,000 inorganic compounds and 4,452 organic compounds. Besides many others, there are also some welcome tables of data on index of refraction of organic compounds, heats of vaporization, heats of combustion, heats of formation, heats of fusion, specific

heats, heats of solution, and standard free energies of compounds. The compiler is to be congratulated on this variety of thermochemical data. However, the table of standard electrode potentials might well have been expanded to include all the known oxidation-reduction potentials. A table of solubilities of inorganic compounds at 10° intervals from 0° to 100° is a unique feature of the volume, but, in common with other tables of solubilities in the current handbooks, this one states solubilities in terms of grams of solute per 100 grams of water, a form in which such data are less often used than the molal basis. It would also be handier if the handbook compilers would give all the thermochemical data on the mole, rather than on the gram basis. The usefulness of such handbooks would be greatly increased, it seems to the reviewer, if they included data on dielectric constants, dipole moments, and magnetic properties of chemical substances, as well as some of the other structural properties of molecules. These properties are rapidly assuming equal importance in the minds of modern chemists with the time-honored thermal properties, and one certainly has as much right to expect data dealing with molecular structure, in a handbook of chemistry, as tables on weights and thicknesses of cast iron pipe.

The format of the Second Edition of the Handbook lives up to the standard of excellence set by the First.

RICHARD O. SUTHERLAND.

Named Lunar Formations, by Mary A. Blagg and K. Müller, Vol. I (Catalogue) and Vol. II (Maps). (Percy Lund, Humphries and Co., Ltd., 12 Bedford Square, London.)

This work was carried on under the auspices of the International Astronomical Union and approved by this organization, upon the recommendation of its Commission 17, at the Meeting held at Cambridge, Massachusetts, in 1932. It was published in 1935.

Volume I, the Catalogue, is an ordinary sized book of 196 pages, listing approximately 5000 lunar features. For each are given a proper name or letter designation, two coördinates to locate it on the moon's surface, a symbol which characterizes the feature, whether crater, rill, etc., the corresponding number in earlier compilations, when there is one, and the name of the person who first named it. It is by far the most extensive list ever published as it is a collation from the writings of such well-known selenographers as Mädler, Neison, Schmidt, and twelve others.

Volume II, the Maps, because of the necessities of the case, is a larger-sized book. In it are found fourteen charts, each covering a section of the moon, the fourteen covering the entire moon. These charts show the detailed features with the designations as given in the catalogue.

These volumes, because of their completeness and their great detail, would be very helpful to one making casual observations of the moon, and indispensable to one wishing to make a critical study of the various markings upon it.

The Catalogue volume contains an introduction by Sir Frank W. Dyson, Chairman of Commission 17 of the International Astronomical Union at the time the work was approved for publication.

C. H. G.

Storrs B. Barrett, for many years an active member of the staff of the Yerkes Observatory, and Associate Professor, Emeritus, since his retirement in 1930, died in Florida on November 25.

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